2020

ECOSYSTEM MONITORING REPORT

EDGARTOWN GREAT POND

GREAT POND FOUNDATION

Ecosystem Monitoring Report - Edgartown Great Pond

Executive Summary

In an effort to document the restoration of Edgartown Great Pond (EGP) and to provide a repository of water quality monitoring data, Great Pond Foundation (GPF) developed its Ecosystem Monitoring Program beginning in 2016. This monitoring program builds on recommendations from previous scientific studies of the Great Pond, namely the Massachusetts Estuary Project report and a study by Arthur Gaines. GPF uses the targets developed in these reports to evaluate the health of the Pond by collecting data at 12 stations across EGP. GPF is committed to gathering as much data as possible on the condition of the Pond to inform management decisions, such as the timing of pond openings. Data from the Ecosystem Monitoring Program is also used to assess the overall efficacy of management activities, such as dredging and breaching of the barrier beach.

Four openings or, "cuts" were attempted in 2020, however, only three were considered successful. The August cut was considered a failure, as it was open for less than 24 hours. The failed summer cut and a severe summer drought delayed the fall cut and led to an unusually long period without an influx of ocean water from a Pond opening. Because of this, salinity was below 15 parts per thousand during the summer and fall. While this was lower than the management target for salinity, it was not critically low, and salinity returned to normal levels after a successful fall cut. Water temperature never surpassed the management target in 2020. Maximum temperature occurred in late July, which was earlier in the summer than previous years. There was a clear seasonal trend in dissolved oxygen, where it was lowest in the hot summer months. Despite some concerning dissolved oxygen measurements, especially in deeper waters, EGP was able to recover quickly to healthy, oxygenated conditions. No macroalgal blooms occurred in 2020. EGP remains one of the healthiest estuaries on Martha's Vineyard and met most restoration management targets.

In addition to the Ecosystem Monitoring Program, GPF continued to forge new collaborations and begin exciting projects. A grant from the Edey Foundation supported a seagrass mapping project in collaboration with the Martha's Vineyard Commission. This project determined there are over 9 acres of submerged aquatic vegetation in Slough Cove, which can potentially store over 500 tons of carbon in the sediment of this cove. This illustrates the enormous capacity for seagrass habitats to sequester and store carbon, which in coastal ecosystems is referred to as blue carbon. Protecting these seagrass species and promoting their restoration is crucial to reducing dangerous carbon emissions and mitigating climate change.

In 2021, GPF will partner with the Marine Biological Laboratories in Woods Hole and the Chilmark Pond Foundation to expand the Ecosystem Monitoring Program. GPF will be monitoring multiple ponds along the south shore of Martha's Vineyard using sophisticated nutrient analysis techniques to gain a more complete understanding of the threats facing Island waters. Additionally, GPF is working with local Boards of Health to develop and implement a cyanobacteria monitoring and response program, which will ensure harmful algal blooms are detected and all stakeholders are notified if these conditions occur. Lastly, sensors will be deployed in multiple locations within the EGP. These sensors will continuously record conductivity/salinity, temperature, and dissolved oxygen. Continuous data collection will enable more precise data analyses and elucidate daily trends in these parameters, leading to a more nuanced understanding of the ecosystem.

2020 Ecosystem Monitoring Data

- *The Pond was cut 4 times in 2020, yet the August cut failed and was open for less than 24 hours.*
- *Salinity was unusually low, due to a failed summer cut and a severe drought which delayed the fall cut.*
- *Water temperatures peaked in late July, which was associated with low dissolved oxygen readings.*
- *Despite some concerning dissolved oxygen measurements, especially in deeper waters, EGP was able to recover quickly to healthy, oxygenated conditions.*
- *EGP remains one of the healthiest estuaries on Martha's Vineyard and met most restoration management targets.*

Overview of Ecosystem Monitoring Program

For the past 5 years, Great Pond Foundation (GPF) has been monitoring water quality within Edgartown Great Pond through the Ecosystem Monitoring Program. Data collection is centered on 12 sampling stations throughout the Pond (Figure 1). These water sampling stations cover all aspects of the EGP ecosystem: from the basin adjacent to the barrier beach, to the deepest parts in the center of the Pond, to the coves in the north. At each station parameters such as temperature, salinity, dissolved oxygen, pH, water clarity and turbidity are measured throughout the entire water column (see Glossary for explanations of parameters). Additionally, concentrations of nutrients such as nitrate, phosphate, and ammonium are analyzed at a select number of stations on each sampling day. In the summer months, the Scientific Program Manager and interns collect water samples twice weekly. Summer is when the Pond is most biologically active, and sampling with high frequency allows for rapid detection of changes or observation of biological phenomena, such as algal blooms. In cooler weather, sampling is performed either weekly or biweekly, depending on weather conditions. Winter prohibits boat-based water sampling, yet the cold weather also limits biological activity making regular sampling unnecessary. In the winter, deployed sensors are the main source of data, such as the water level logger that measures Pond elevation. GPF recently purchased a dissolved oxygen sensor and two salinity sensors that will continuously monitor these parameters, further enhancing GPF's ability to monitor water quality in 2021.

Figure 1. Water sampling stations in Edgartown Great Pond.

Despite challenges posed by the COVID-19 pandemic, GPF was able to continue the Ecosystem Monitoring Program with the help of the 2020 Summer Science Intern, Ben Emery. The 2020 field season began on May 6th and the last water sampling collection occurred on November 25th. There were 42 sampling days across 7 months, providing a large high-resolution dataset from the end of spring to the beginning of winter. These data can answer many questions about the health of the Pond and add to the growing database of water quality data in EGP.

Pond Cuts

- *Four cuts were attempted in 2020, yet only three were successful. A failed summer cut and a severe summer drought led to an unusually long period of time without an influx of ocean water from a cut.*

The barrier beach was breached to the ocean four times in 2020, however, the August cut closed in less than 24 hours and was deemed unsuccessful (Table 1). Following a cut, salinity is often used to measure of the extent of exchange between the Pond and the ocean and determine the success of the opening. However, salinity data are not always available, such as during the offseason when sample collection does not occur. Salinity data from previous cuts indicate a successful pond flush occurs after a 10-day opening. An increase of at least 10 parts per thousand (ppt), especially in the coves, indicates a successful flush where salty ocean water is introduced throughout the entire Pond. The 3/22 cut occurred prior to the beginning of water sampling, so no salinity data was collected. However, this opening lasted for 10 days, which suggests this opening was successful.

Cut Number	Date	Approximate Duration of Opening
1	3/22/2020	10 days
2	5/17/2020	9 days
3	8/22/2020	1 day
4	11/7/2020	11 days

Table 1. List of cut dates and duration in Edgartown Great Pond.

The May 17th cut occurred at the beginning of the field sampling season. Prior to the cut, salinities throughout the Pond were 14.8 – 17.5 ppt. After the cut, salinities increased by up to 12.5 ppt in the main basin, but salty ocean water failed to reach up into the coves of the Pond (Figure 2). This indicates that the Pond was not fully flushed and that the cut was only somewhat successful. The summer cut, which occurred on 8/22 was a failed cut. The beach was breached for less than 24 hours before it closed. The cut was performed when the pond height was 3.2 feet above sea level, and ideal height for successful openings is at least 3.5 feet above sea level. This cut did not result in an increase in salinity, and the pond dropped less than half a foot. The region experienced a severe drought in the summer of 2020, which contributed to an unusually long recharge time for the pond to fill.

Following the failed summer cut, the Pond required 2 months to regenerate it's water level to a point when another cut could feasibly be made. Due to the failure of the August cut, GPF advocated to the Town of Edgartown to wait until the Pond was at least 3.5 feet above sea level to make the fall cut. It was crucial to maximize the efficacy of the fall cut, despite the 6-month duration between successful openings. On 11/7/20 the Pond was cut a fourth time, when the pond elevation was 3.5 feet above sea level. This cut remained open until 11/18/20, for an 11-day period. Pond elevation data indicate that the pond drained and became tidal, while salinity data show that cooler, salty ocean water flushed the majority of the Pond. Salinity rose by 12-16 ppt at most stations 6 days after the fall cut, while the coves experienced a delay in salinity change due to persistent influx of fresh groundwater (Figure 3). By the end of the field season, all stations were higher in salinity, signaling a full exchange of water with the ocean and indicating a successful cut.

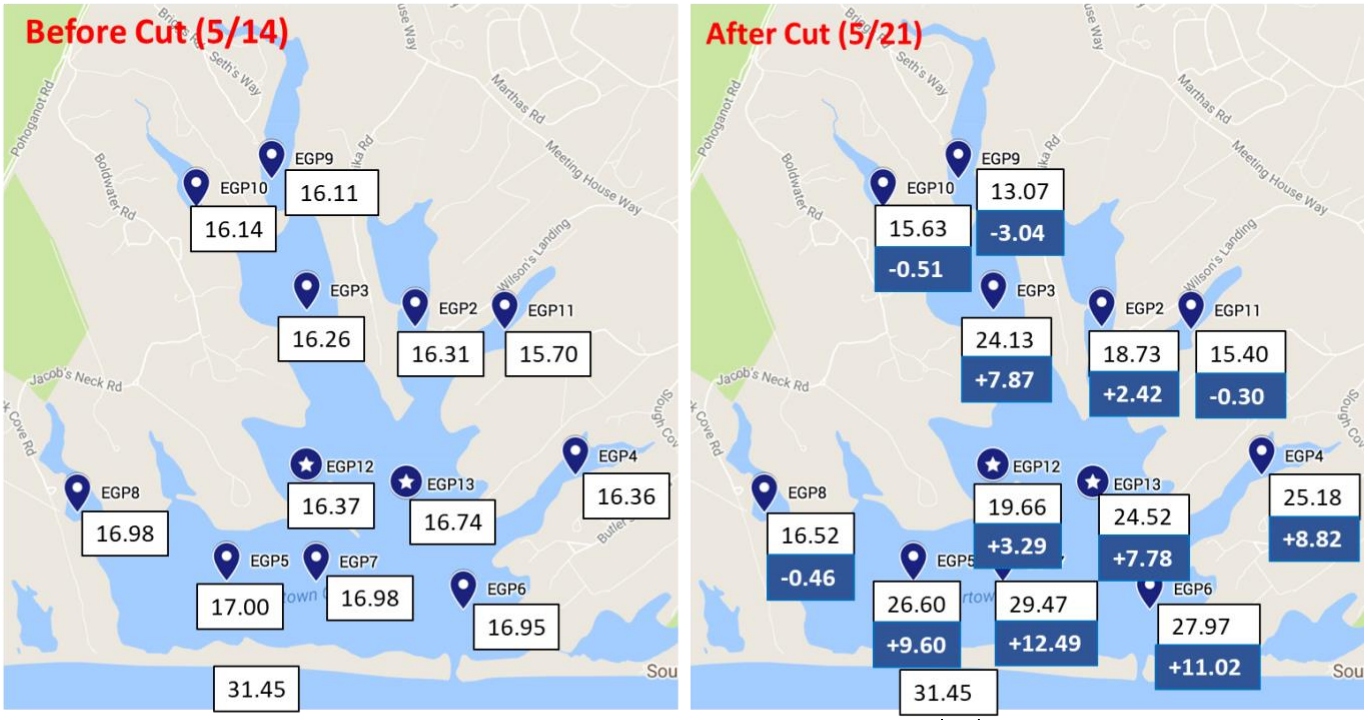

Figure 2. Salinity at each station 3 days before and 4 days after the spring cut (5/27/20). Numbers are bottom salinity measured in parts per thousand (ppt), with the change in salinity shaded in dark blue.

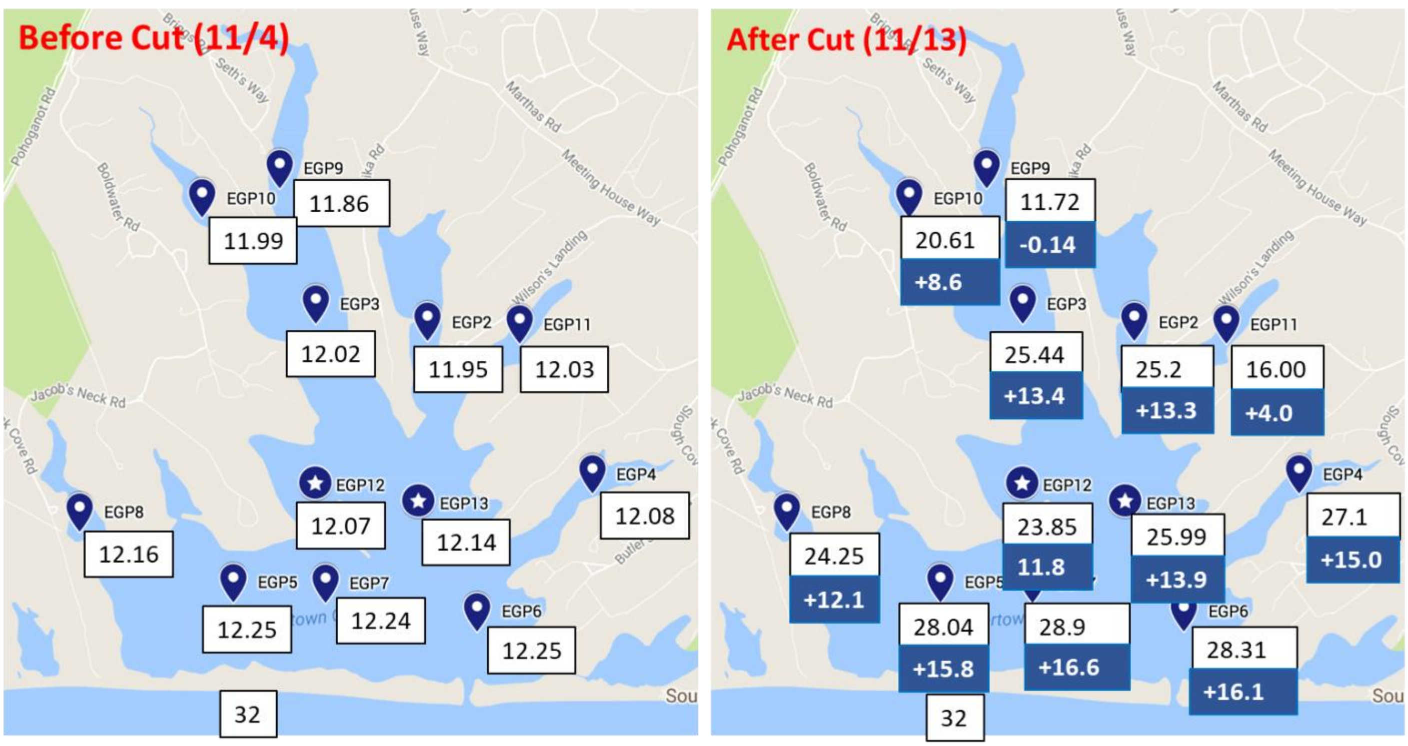

Figure 3. Salinity at each station 3 days before and 6 days after the fall cut (11/7/20). Numbers are bottom salinity measured in parts per thousand (ppt), with the change in salinity shaded in dark blue.

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Salinity

- *Salinity was below 15 parts per thousand during the summer and fall due to a failed summer cut and a severe drought which delayed the fall cut. While this was lower than the management target for salinity, it was not critically low, and salinity returned to normal levels after a successful fall cut.*

Salinity in EGP in 2020 was unusually low for the majority of the field season. Specifically, salinity was below 15 parts per thousand (ppt) throughout the whole Pond from June until the fall cut on 11/7. Salinity below 15 ppt is threatening to the eelgrass (*Zostera marina*) that lives within the Pond, as this species prefers saltier water closer in salinity to ocean water (ocean water = 32 ppt). When Pond salinity falls below 15 ppt it becomes a stressful environment for eelgrass, while salinity below 10 ppt can be fatal. Eelgrass is an extremely important species, as it creates habitat for other aquatic organisms while stabilizing the sediment, improving water clarity, and removing and storing carbon from the atmosphere. For these reasons, GPF closely monitored salinity and pond height in 2020, and advocated for a cut to the ocean as soon as it was feasible. Breaching the barrier beach to the ocean is the only way to introduce salty water to the pond, which raises the salinity.

The prolonged period of unusually low salinity was caused by a combination of different factors. First, the spring cut was not fully successful and did not stay open long enough to allow salty water to reach into the coves of the Pond. This, followed by a failed summer cut, limited the amount of salt water which entered the Pond. Further, the failed summer cut lowered the Pond elevation without introducing ocean water, which delayed subsequent reopening until the water level reached sufficient height. The length of time between the summer and fall cuts was exacerbated by a drought that occurred in summer 2020. During this period, the watershed experienced very little rain, limiting the rate at which the Pond could refill.

The impact of the cuts on salinity can be seen when viewed over the entire field season (Figure 4). The 5/17 cut increased salinity at most stations, however, ocean water failed to reach the coves (EGP9, EGP10, EGP11). During this period, the cut closed before the entire Pond was flushed, shortening the duration of higher salinity typically observed during and after an opening. At all stations, salinity quickly declined to pre-cut salinities and subsequently continued to decline due to fresh groundwater flow. Salinity was lowest in the coves with groundwater springs (EGP9 & EGP10). Surface water, which is fresher than bottom water due to the density increase caused by salt ions, fell below 10 ppt at these stations numerous times. Eelgrass and other important species such as shellfish live on the bottom, and bottom water salinity never fell below the 10 ppt threshold. Minimum bottom water salinity was 11.72 at EGP9, where the lowest salinities occurred before and immediately after the 11/7 cut. All stations received salty ocean water after the fall cut, leading to a large jump in salinity from 11-12 ppt to 21-23 ppt (Figure 4). Monitoring stopped on 11/25/21, yet this cut was successful and sufficiently increased the salinity pond-wide, a favorable position for the beginning of the winter season.

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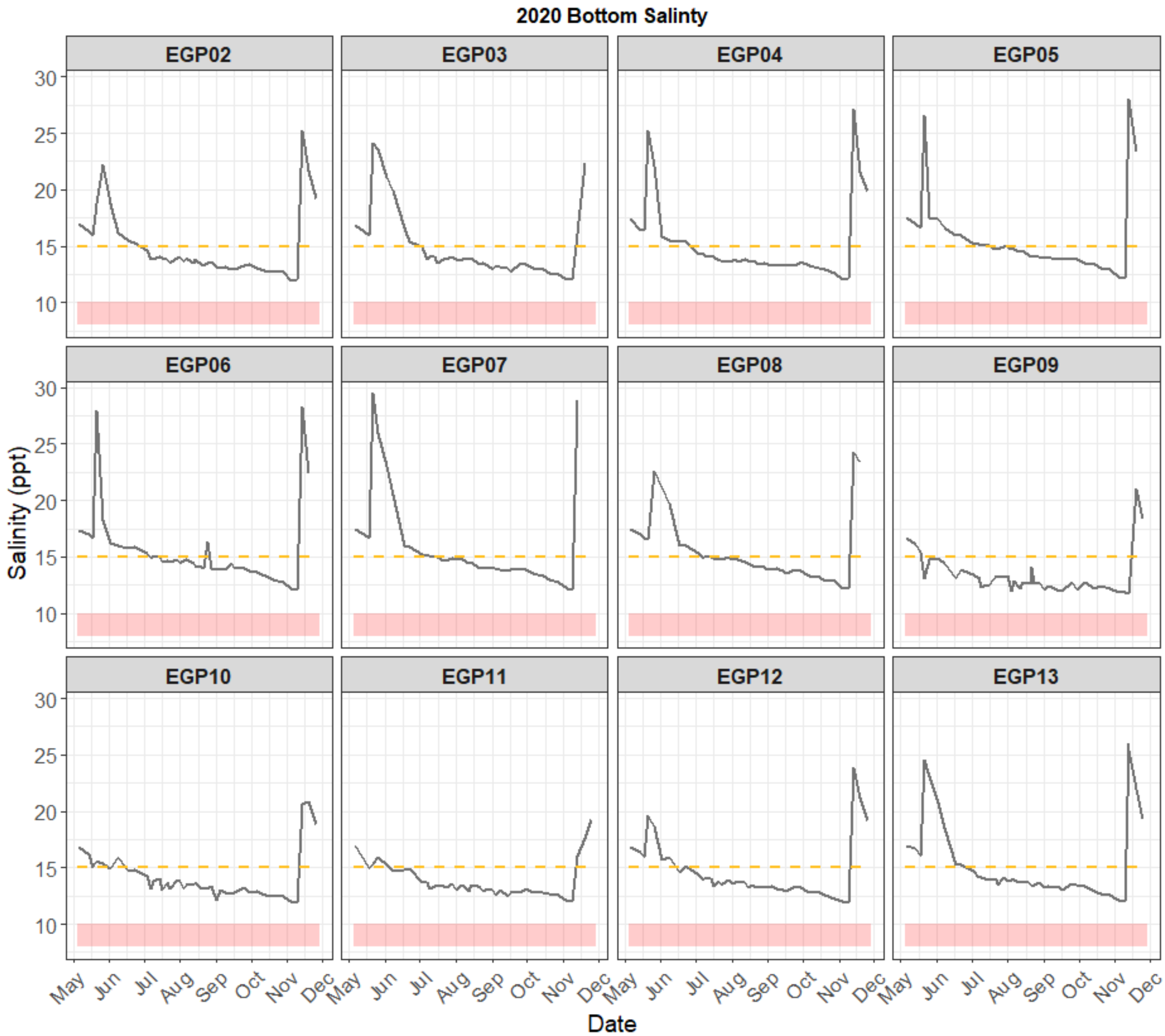

Figure 4. Salinity at each station throughout the field season. Salinity was measured at the bottom on the water column in parts per thousand (ppt). Large spikes in salinity occur after the Pond was cut to the ocean.

Temperature

- *Water temperature never surpassed the 85°F management target in 2020. Maximum temperature occurred in late July, which was earlier in the summer than previous years.*

Another important parameter to monitor is temperature. Much like the temperature of our own bodies, elevated water temperature is often associated with problems affecting ecosystem health. The EGP management goal is to maintain water temperatures of less than 85° F during the summer. However, unlike other parameters that can be influenced by management decisions, there is no way to control temperature.

Temperature is measured throughout the water column at all stations across the Pond. Water monitoring occurs in the cooler early mornings, so data likely underestimate peak daily temperatures. Maximum water temperature occurred at the end of July and beginning of August in 2020 (Figure 5). July 29 was the hottest day, followed by August 4, where temperatures reached 84.9° and 83.1°F, respectively. The stations with the hottest

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temperatures were EGP9, EGP10, and EGP11, which are located in shallow parts of the Pond. While water temperature reached the 85°F threshold once at the end of July at EGP9, mid-depth temperatures never exceeded this thermal limit.

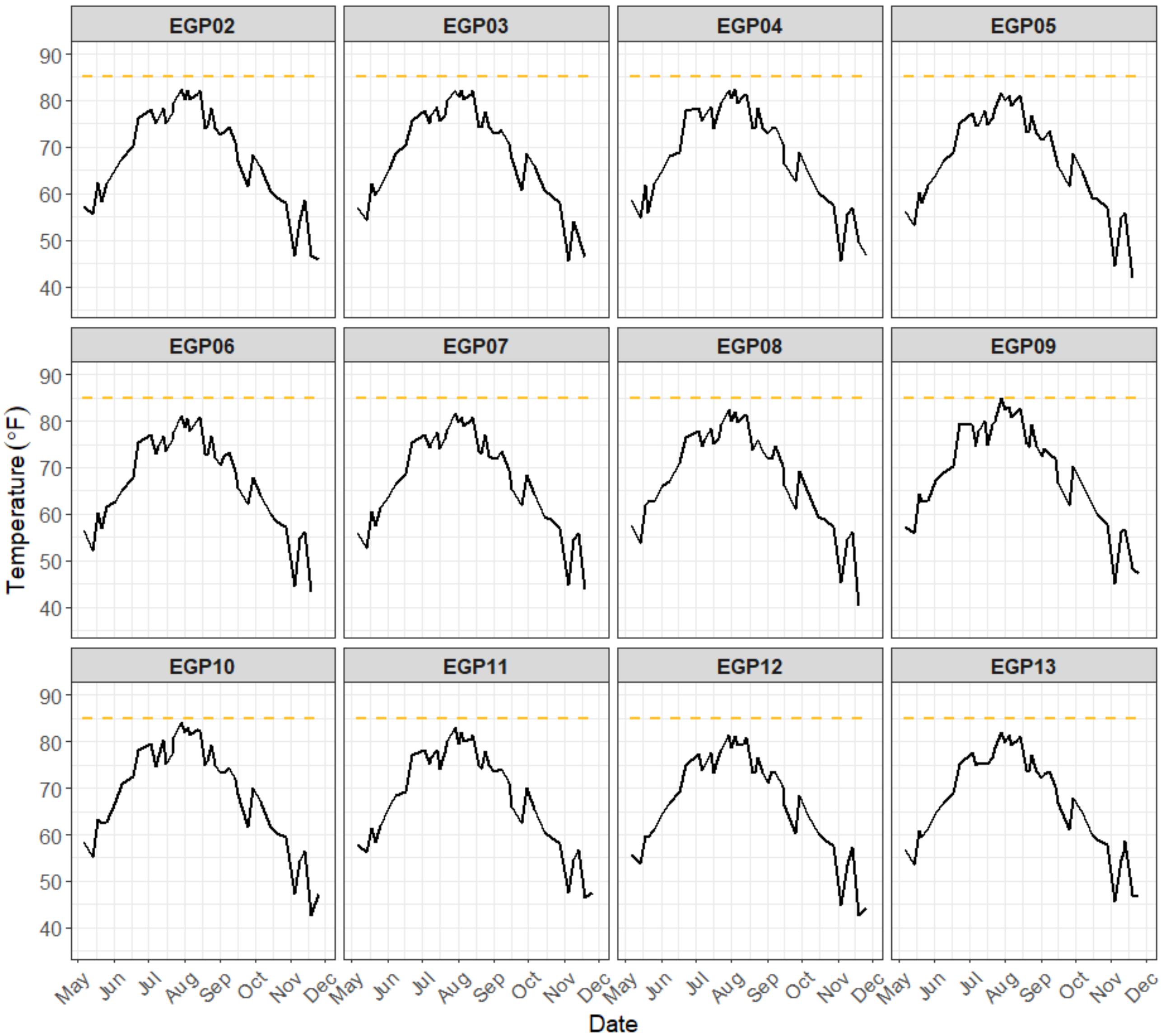

Figure 5. Temperature at all sampling stations from May through November. Measurements were taken at mid-depth, as it approximates average temperature throughout the water column. The dashed yellow line represents the management target of 85° F.

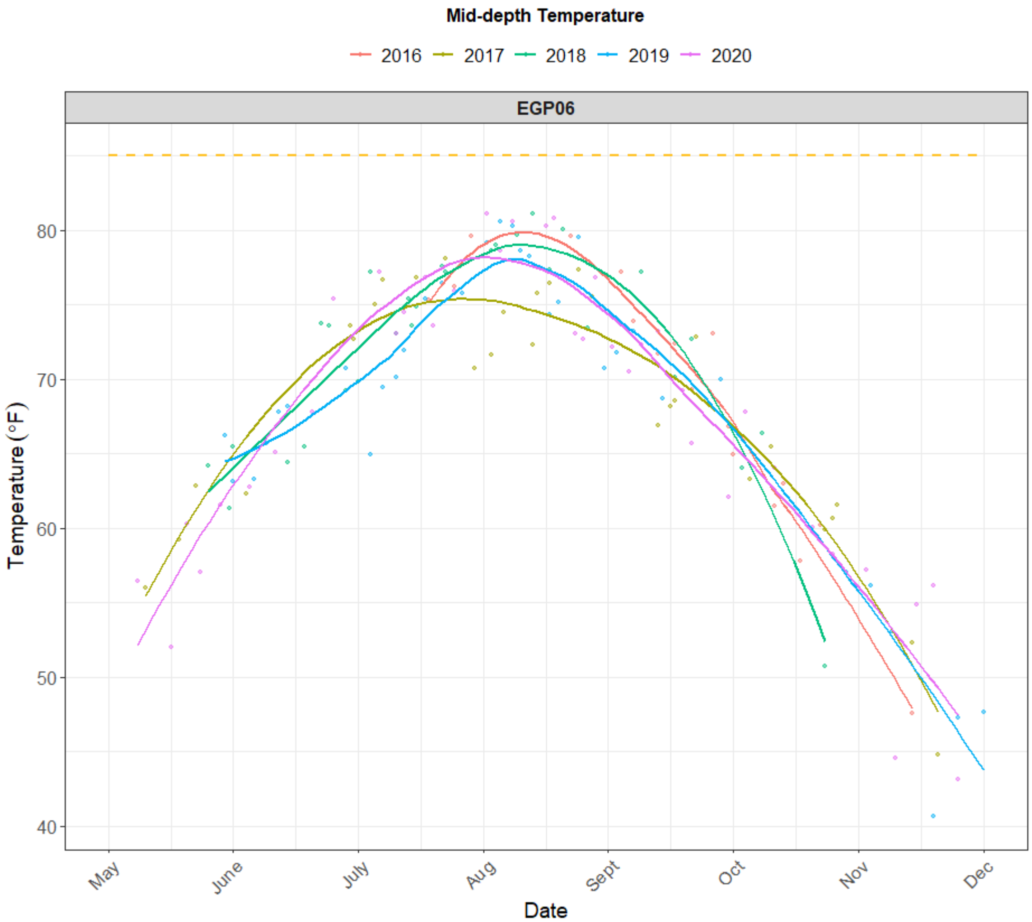

Figure 6. Mid-depth temperature readings at station EGP6 over the duration of the Ecosystem Monitoring Program. EGP6 has the longest temperature timeseries, which allows comparison of temperature trends between years. The dashed yellow line represents the management target of 85° F.

The GPF Ecosystem Monitoring Program has been collecting data at all 12 stations since 2016. This timeseries allows for comparison between years, as it is especially helpful to compare temperature trends at this scale. In recent years, peak summer temperatures have shifted from August to mid-late July (Figure 6). The rate at which the Pond heats up in the spring and early summer and the maximum temperature varies each year. Early July was hottest in 2020, however 2016 and 2018 experienced higher maximum temperatures. 2020 and 2019 were very similar in maximum temperature, yet the timing of this peak was earlier in the summer in 2020 compared to 2019. This will be an interesting trend to continue to monitor, as these data will allow impacts from climate change to be detected.

Dissolved Oxygen

- *There was a clear seasonal trend in dissolved oxygen (DO), where it was lowest in the hot summer months. The deepest water sampling stations experienced the worst DO depletions, however these depletions were brief and DO always recovered quickly.*

Edgartown Great Pond continues to experience brief periods of low dissolved oxygen (DO) in some parts of the Pond. DO refers to the amount of oxygen available for consumption by marine species and is essential to the metabolism of plants and animals in an estuarine ecosystem. The management threshold for DO is 6 milligrams per liter (mg/L), while organisms will begin to experience oxygen deprivation at DO levels below 4 mg/L. Low levels of DO can inhibit the growth of plants and animals and can even cause mortality in cases of prolonged or severe oxygen depletion. However, the amount of oxygen that can physically dissolve in water is negatively related to both temperature and salinity. Colder, fresher water can hold more oxygen molecules than warmer, saltier water. This has major implications for EGP, since both temperature and salinity can change rapidly after the Pond is opened. Since the summer cut closed within 24 hours in 2020, a rise in salinity did not impact the amount of oxygen dissolved in the water.

Normally, the bottom of the water column has lower DO than surface waters. This is because oxygen mixes from the air into the water at the surface, and most plants, which produce oxygen, are found at the surface where there is direct sunlight. Additionally, decomposition of organic matter occurs on the bottom and in the sediments, which consumes oxygen. Due to these processes, deeper water often has lower dissolved oxygen than the surface. This can be clearly seen when DO from surface, mid-depth, and bottom waters are plotted together on the same graph. At all except the most shallow stations (i.e. EGP 11), there was a depth gradient in oxygen concentration, where DO dropped with increasing depth (Figure 7). This gradient became more severe during the summer season, as the pond experienced the hottest temperatures of the year. There was a clear

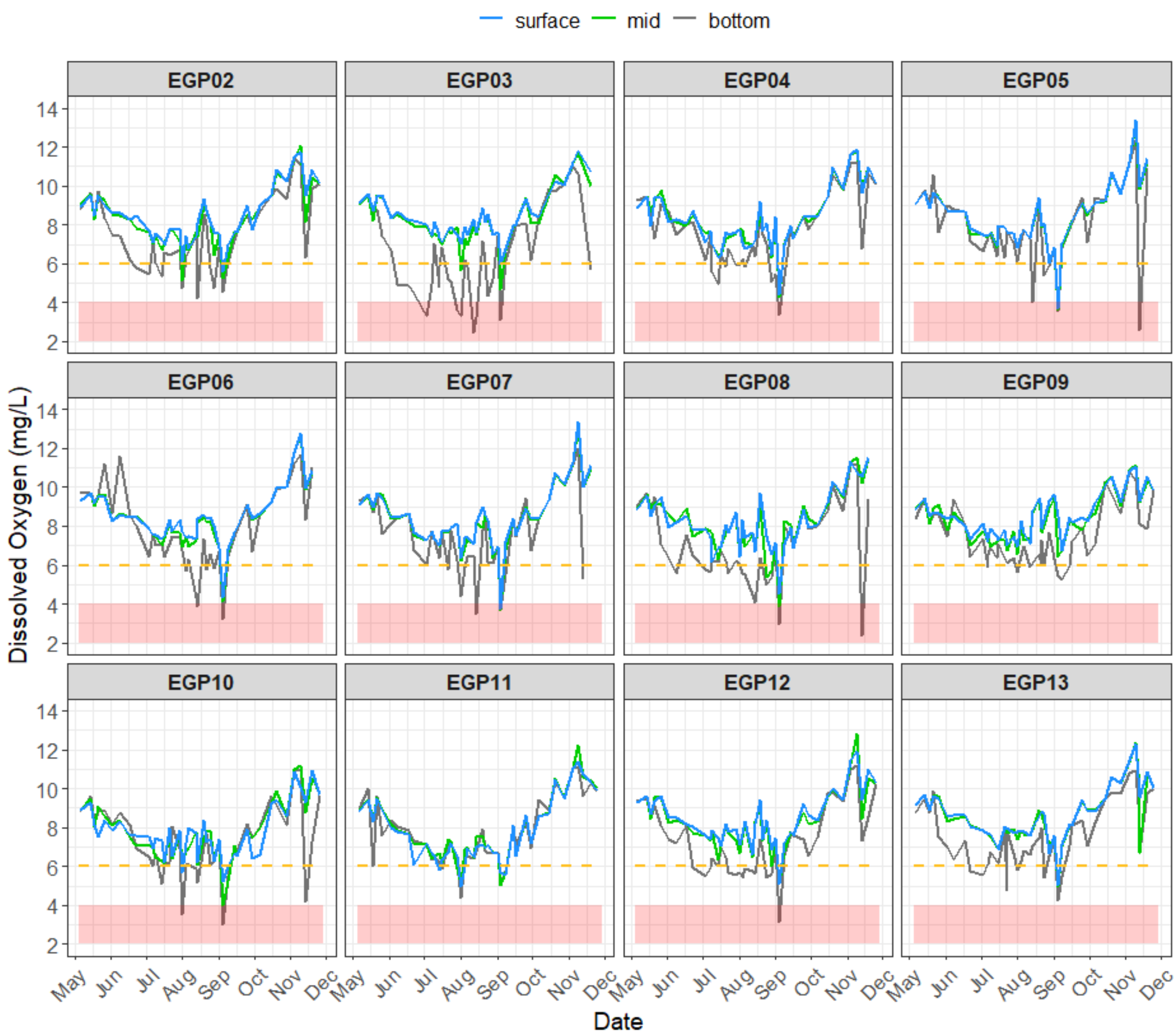

Figure 7. Dissolved oxygen at all sampling stations from May through November. Measurements were taken at the surface (blue), mid-depth (green), and bottom (gray). Bottom dissolved oxygen was consistently lower than measurements taken higher in the water column. The yellow dashed line represents the 6 mg/L management target, while the shaded red area is when DO becomes critically low, below 4 mg/L.

seasonal trend, where DO at all depths was reduced during the hot summer months. An exception to this trend occurred when DO levels dropped on 11/13/20, which was after a spike in salinity caused by the fall cut. Cuts cause rapid changes in the biology of the Pond, which can sometimes elicit shifts that temporarily lower DO.

Elevated temperatures that occur in the summer months lead to multiple factors which lower the DO in the Pond. Between mid-June to mid-September, all stations experienced DO which dropped below the 6 mg/L threshold at least once (Figure 8). Most often this was limited to measurements taken at the bottom and these drops below the 6 mg/L threshold were usually brief. DO rarely fell below the 4 mg/L threshold into the zone of concern, where oxygen deprivation can begin to occur. These declines in DO occurred on 7/3, 7/29, 8/1, 8/12, 8/14, 9/4 and 11/13 and were primarily observed at stations EGP3, EGP7, EGP8 and EGP10.

Figure 8. Dissolved oxygen (DO) at all sampling stations during the summer, when DO is lowest. Measurements were taken at the surface (blue), mid-depth (green), and bottom (gray). Bottom DO was consistently lower than measurements taken higher in the water column, and lowest at the deepest stations. The yellow dashed line represents the 6 mg/L management target, while the shaded red area is when DO becomes critically low, below 4 mg/L.

Station EGP3 experienced the most frequent number of low DO measurements (Figure 8). This is likely due to EGP3's location in one of the deepest parts of the Pond, where factors such as stratification and light transmission through the water column affect oxygen concentration. At greater depths, the water column can become stratified, where differences in temperature and density create layers within the water. This stratification makes it increasingly difficult for oxygen to infiltrate to greater depths. Additionally, the water is often too deep for light to reach to the bottom, which inhibits the growth of submerged aquatic vegetation, such as eelgrass or widgeon grass. With constrained sources of oxygen, bottom water at deep stations becomes depleted of oxygen as it is consumed by species' metabolisms and via chemical processes such as decomposition of organic matter in the sediment. As such, bottom water measurements at EGP3 were below the 6 mg/L threshold for the majority of the summer in 2020 (Figure 9). Further, there were 4 days where the DO fell below the 4 mg/L limit, indicating a harmful environment for organisms. These critically low DO measurements were associated with spikes in water temperature.

While water quality at station EGP3 was challenged by low dissolved oxygen, data indicate this was localized to deeper areas of the Pond, and the majority of EGP had sufficient oxygen levels to sustain life. Declines below the management thresholds were temporary, which show the Great Pond is healthy and able to recover from threatening conditions. It is common for lakes and estuaries to struggle with low dissolved oxygen in the summer, and low DO is most alarming when it is sustained for long periods of time. Further, sampling protocols were designed to capture the DO at its lowest point in its daily cycle. Plants cease to photosynthesize and produce oxygen at night, while most organisms will continue to consume it. GPF water sampling occurs shortly after sunrise when oxygen levels are at their minimum. If sampling were to occur later in the day, DO measurements likely would be higher. In 2021, a dissolved oxygen logger will be installed in the Pond to track the daily DO cycle and continuously collect data, so measurements will not be limited to sampling days. This will be an extremely valuable tool to track the health of the ecosystem more closely.

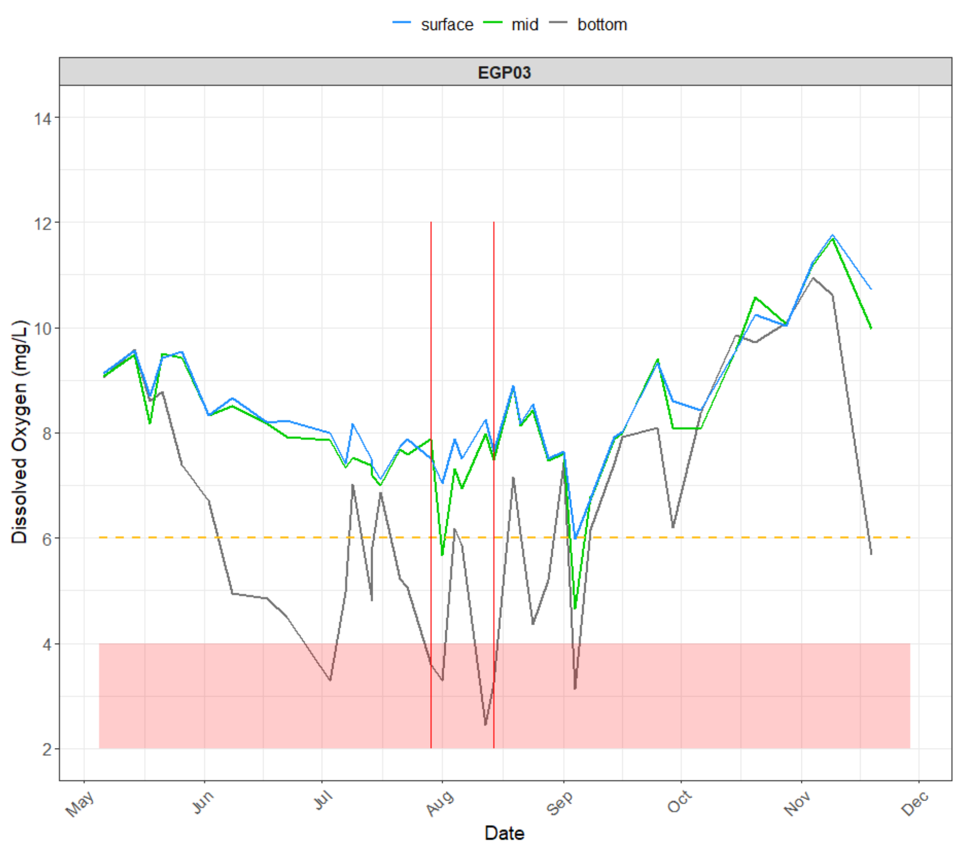

Figure 9. Dissolved oxygen (DO) at station EGP3, the station with the lowest DO. Measurements were taken at the surface (blue), mid-depth (green), and bottom (gray). Bottom dissolved oxygen was consistently below the 6 mg/L management target and occasionally fell into the critical zone below 4 mg/L (shaded red). Oxygen depletion was associated with temperature peaks, with the two highest temperatures depicted with the red lines.

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Water Clarity

- *While water clarity was generally good in 2020, Secchi depth, a measure of turbidity, was often below the management target in the summer months. The long period of time between cuts due to the failed summer opening likely contributed to this. Yet, no major macroalgal blooms occurred in 2020.*

Water clarity is often assessed with turbidity, which is a measure of suspended particulate matter in the water. Water with low turbidity is clear and you can often see the bottom, while water with high turbidity appears murky. Water with high turbidity is detrimental to submerged aquatic vegetation, as less sunlight can penetrate the murky water, limiting plant photosynthesis. The particles that cause high turbidity can be either living or nonliving. Living particles include microscopic plants called phytoplankton and other microscopic organisms that often reproduce quickly causing the water to appear green or brown in color. Elevated concentrations of nutrients and increased temperatures can stimulate growth of these microscopic species. Nonliving particles are typically comprised of sediment which was either resuspended from the bottom of the pond or entered the water via runoff from land. Because of this, murky or turbid water is common after rain events.

GPF measures water clarity in two ways, with a sensor and with a Secchi disk. A Secchi disk is a standardized black and white disk attached to a measuring tape that is lowered into the water. The depth at which it disappears from view corresponds to the depth at which turbidity is too great for light to penetrate into the water column. The management goal is to have sufficient water clarity to see the Secchi disk 3 meters (9.8 feet) down, or on the bottom of the Pond.

In Edgartown Great Pond (EGP), turbidity is often caused by high densities of plankton in the water column. Due to increased temperature and amount of sunlight, this is more likely to occur during the summer months. Since EGP is less than 3 meters (m) deep at all but two stations, the management goal is to be able to see the Secchi disk on the bottom. Almost all sampling stations experienced an increase in turbidity and subsequent decrease in Secchi depth in July and August, except at EGP11, the shallowest station (Figure 10). While Secchi depth was consistently less than the management target, water clarity was not diminished enough to severely impact submerged plants. The Pond did not get flushed during the summer, since the August cut failed, a factor which contributed to the increase in turbidity.

The conditions that favor proliferation of plankton also favor macroalgal blooms. In the past, EGP has experienced widespread green algal blooms that blanketed parts of the Pond. However, a large bloom was not detected in 2020. This is an indicator of improved water quality, as macroalgal blooms have many negative implications for overall Pond health. Additionally, the low salinity within EGP may have reduced the likelihood of an algal bloom occurring.

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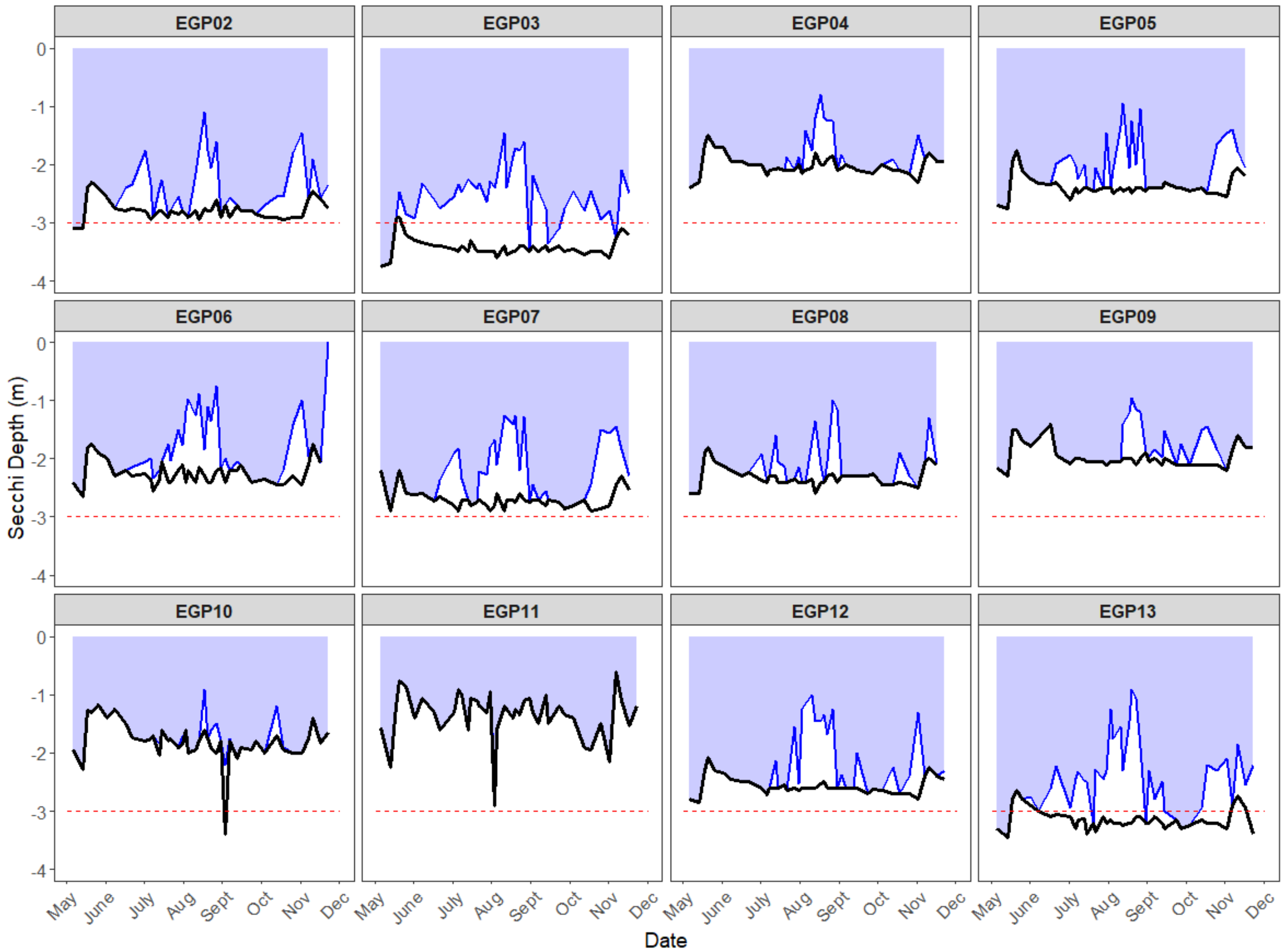


Figure 10. Secchi depth and total depth in meters at each station. Secchi depth is the depth at which a standardized disk disappears from sight, and often corresponds to total depth. Total depth in the figure is the thick black line, and Secchi depth is the blue shaded area above the blue line. The management target for Secchi depth to equal total depth, or be at least 3 meters (dashed red line).

Projects and Collaborations

While 2020 was a challenge in many ways due to the COVID-19 pandemic, GPF was able to continue working with collaborators and pursue new projects. One exciting new project was a collaboration with Chris Seidel at the Martha's Vineyard Commission to map eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*) beds in Slough Cove and calculate the amount of buried carbon, called blue carbon, stored in this part of the Great Pond. This project was made possible through the generous support of the Edey Foundation. Nearly 1,500 high resolution aerial images were taken of Slough Cove via a drone and stitched together to form a composite image. From this composite image, seagrass beds were delineated using two Geographic Information Systems (GIS) techniques, the results of which determined that there are over 37,000 square meters (>9 acres) of seagrass in Slough Cove (Figure 11). Coastal seagrasses are very effective at removing carbon from the atmosphere and storing it underground. In fact, this blue carbon can be stored in the sediments for centuries, if not longer. This project determined that there are potentially 500 tons of carbon stored beneath the pond floor in Slough Cove alone. If the eelgrass and widgeon grass were to disappear, a common symptom of deteriorating water quality, this stored carbon will likely be released back into the atmosphere. When water quality improves as a result of restoration efforts, conditions are cultivated which allow eelgrass to proliferate. Protecting these seagrass species and promoting their restoration is crucial to reducing dangerous carbon emissions and mitigating climate change. Thus, protecting Island coastal ecosystems is an investment in local conservation with a global impact. These impacts are explained in two infographics which GPF uses in educational materials (located in Appendix), which were created by local artist John Holladay with support from the Edey Foundation.

Additionally, GPF began working with our Pond neighbors to begin monitoring Crackatuxet Pond. This pond is hydrologically connected to EGP via groundwater, and EGP will flow into Crackatuxet via the sluiceway when Pond elevation is high. Both ecosystems share similar challenges, and it is important to fully understand both in order to restore the ecosystem as a whole. Beginning in the fall of 2020 and continuing into 2021, GPF will monitor Crackatuxet with both boat-based and deployed sensor methods. This will allow a more complete understanding of the impairments and potential management solutions.

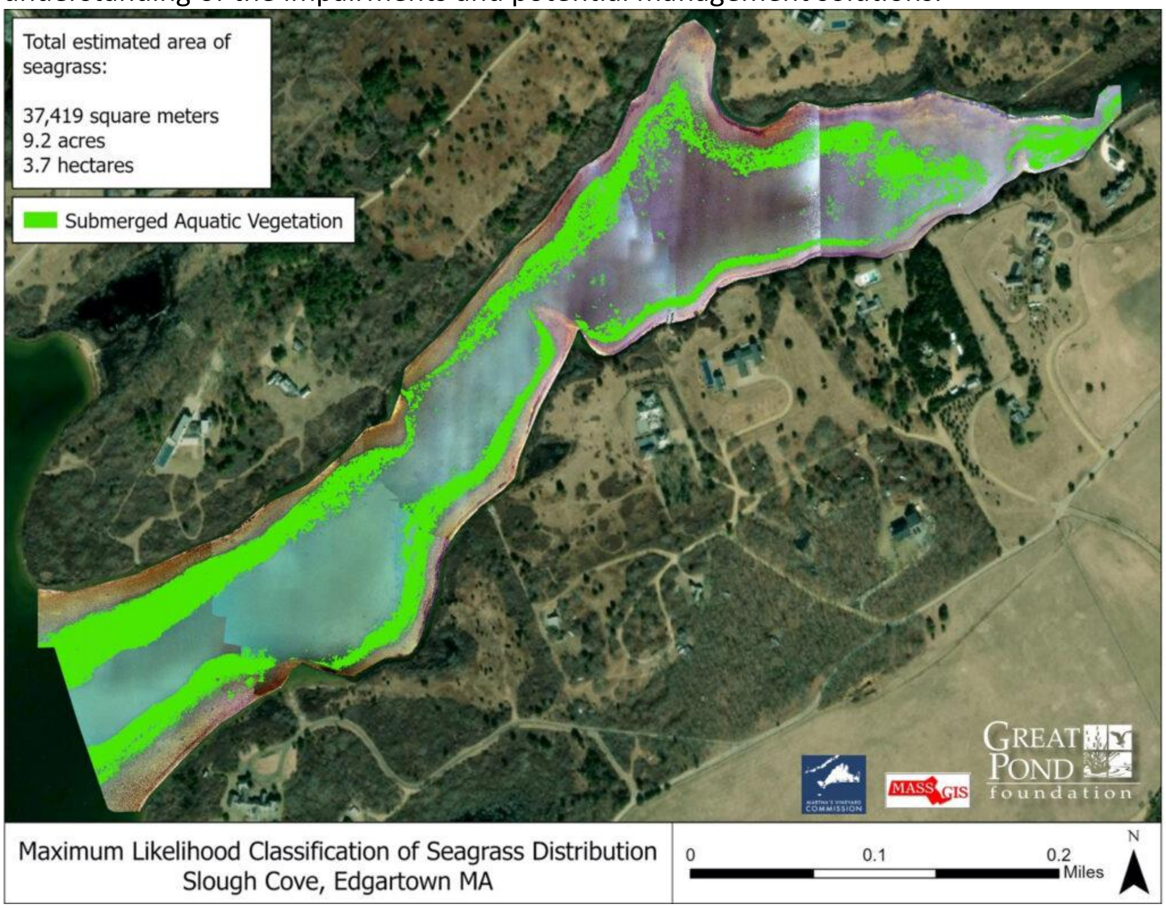


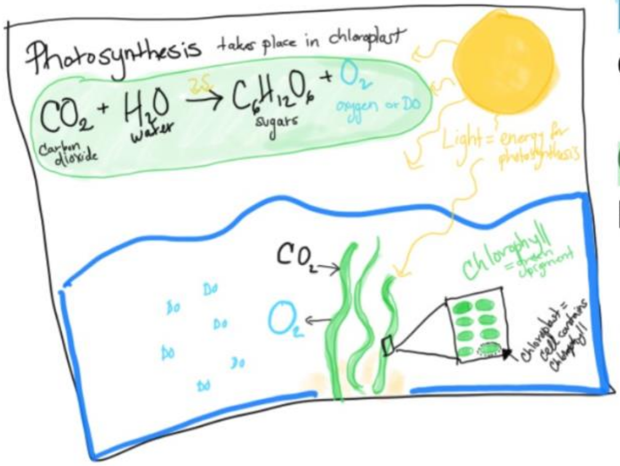
Figure 11. Delineation of seagrass beds in Slough Cove, Edgartown Great Pond. This image is a composite of nearly 1,500 high resolution drone photographs, which allows for total seagrass area to be calculated.

2021 Monitoring Plan

The upcoming 2021 field season will be a historic year for Great Pond Foundation. With new partnerships with the Chilmark Pond Foundation and Marine Biological Laboratories (MBL), GPF will expand monitoring to additional Island ponds using numerous techniques to understand the challenges facing these ponds. In Edgartown Great Pond, the Ecosystem Monitoring Program will continue to collect data on water quality and biodiversity weekly May through November and twice weekly during the summer. Additionally, recently purchased sensors will be deployed in multiple locations within the Pond. These sensors will continuously record conductivity/salinity, temperature, and dissolved oxygen. Continuous data collection will enable more precise data analyses and elucidate daily trends in these parameters, leading to a more nuanced understanding of local ecosystem processes. Further, the partnership with MBL includes more frequent and more extensive nutrient sample collection and analysis. This work will pinpoint where nutrients such as nitrogen and phosphorous are entering the pond, and will determine the source of these nutrients, such as fertilizer, septic systems, farm runoff or atmospheric deposition. All of this work will lead to a more complete understanding of the dynamics within Edgartown Great Pond and help inform data-driven management and restoration efforts.

Additionally, GPF will begin to monitor EGP for cyanobacteria. Cyanobacteria, also called blue-green algae, are naturally occurring species in marine and aquatic ecosystems. Most species are harmless; however, some species are known to produce toxins. In small quantities, these pose little danger, yet potential risks to human and animal health arise when these species rapidly reproduce and form an algal bloom. The most dangerous species have yet to be documented in EGP, as these species prefer water with lower salinity. However, because of the important health implications GPF is developing a monitoring and response plan. Samples for cyanobacteria and other types of microscopic plants will be collected weekly or more frequently if necessary. GPF is working directly with Matt Poole, of the Town of Edgartown Board of Health, to develop a response plan for when/if these species are detected and how to effectively communicate with stakeholders when needed. Due to the elevated salinity in EGP, GPF does not anticipate a harmful cyanobacteria bloom but will be actively monitoring to ensure the highest degree of safety.

Visual Glossary: **Water Quality Parameters**

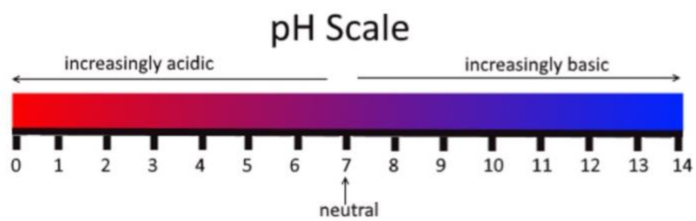


Dissolved Oxygen (DO): the amount of oxygen (O_2) dissolved in water, measured in milligrams per liter (mg/L).

Chlorophyll: Chlorophyll is a pigment plants use for photosynthesis, measured in micrograms per liter (µg/L).

Photosynthesis = the process by which green plants and algae make food (sugar) using carbon dioxide and water.

pH: a measurement of how acidic or basic a solution is. Neutral pH is 7.



Salinity: the amount of salt dissolved in water, measured in parts per thousand (ppt). Ocean salinity is 32-35 ppt, while freshwater is 0 ppt.

Turbidity: a measure how many particles are dissolved in the water, which affects water transparency. Water with high turbidity appears murky.

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, which can be harmful to the health of a body of water.

Visual Glossary: **Healthy & Impaired Ecosystems**

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.

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.

Algal Bloom: a sudden and rapid increase in growth of aquatic plants. Algal blooms can occur with microscopic phytoplankton, or larger macroalgae (AKA "seaweed").

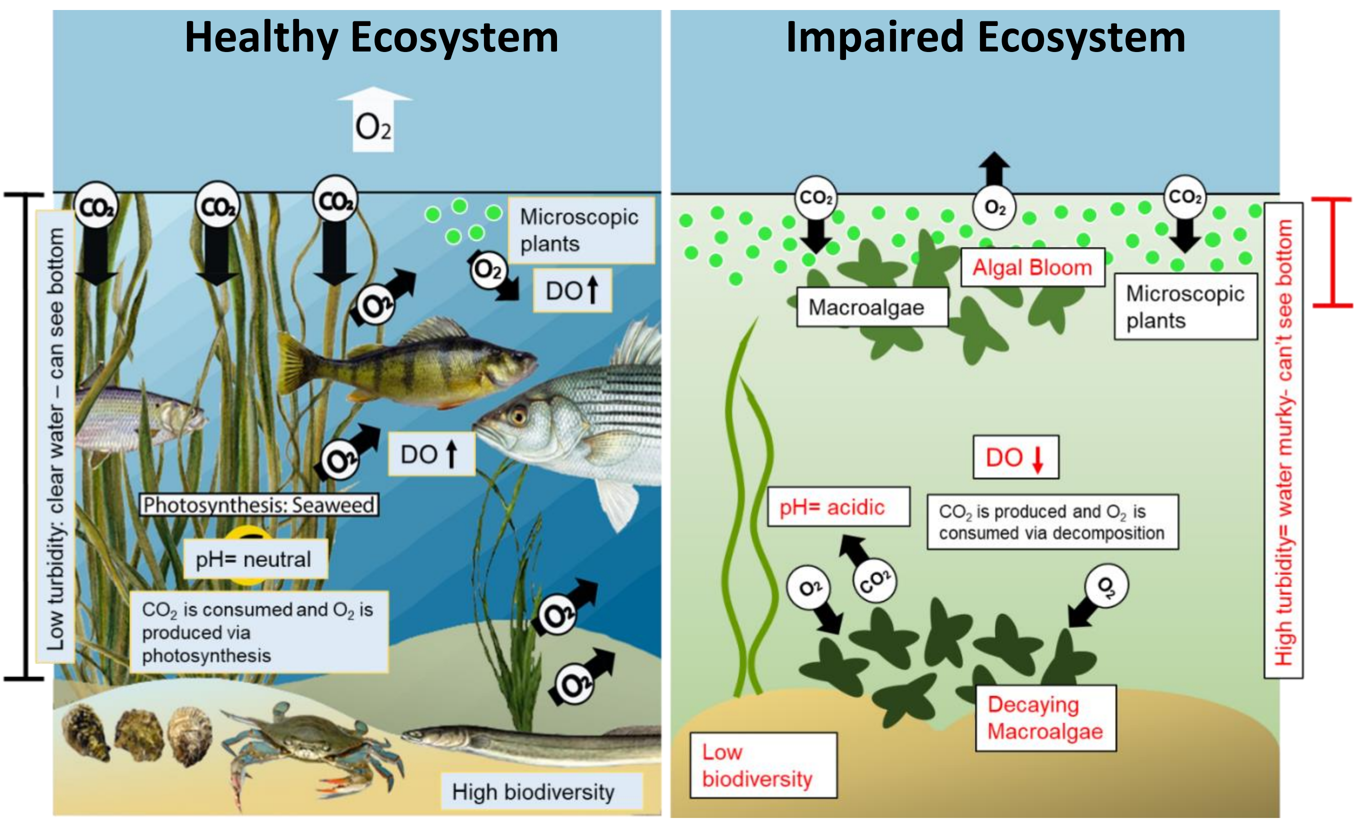
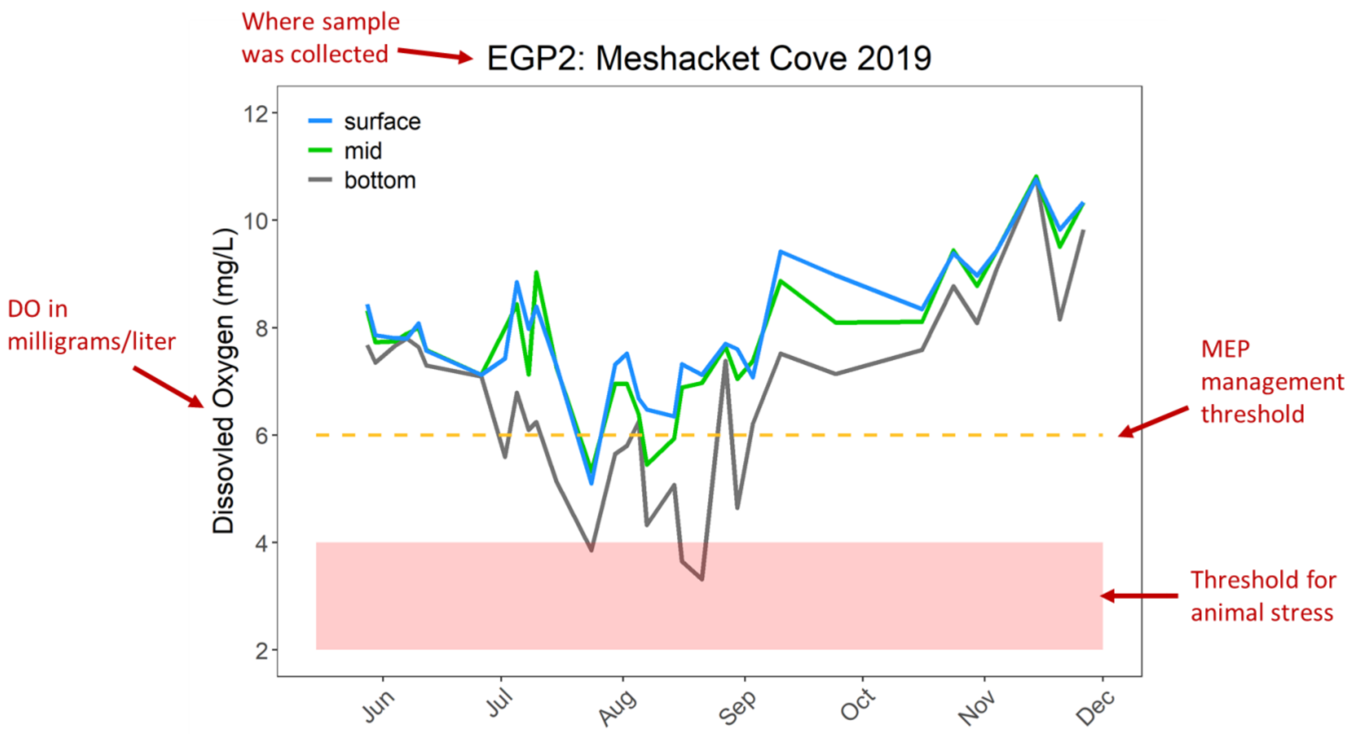


Illustration of a healthy ecosystem compared to one that is impaired. The healthy ecosystem (left) is biodiverse with excellent water quality and high levels of dissolved (DO). This is in contrast with the impaired ecosystem (right), which is experiencing an algal bloom and suffers from poor water quality and low biodiversity.

Making Sense of the Figures



Fundamental to understanding data is reading and deciphering a graph. Graphs are key tools scientists use to visualize numerous data points in one place. Without graphs, there would be thousands of data points and extracting trends from these numbers would be impossible. A good graph is self-explanatory, but it is important to understand all the components in order to fully ascertain the data.

Most graphs have two variables: the independent variable and the dependent variable. The independent variable is usually along the x-axis (horizontal) and is a parameter that does not depend on any other variable, such as date. The dependent variable is on the y-axis (vertical), usually on the left, is the parameter of interest in a plot. This variable is affected by changes in the independent variable, such as how temperature fluctuates with time. It's important to always look at the scale on the axes, because it shows the magnitude of change.

Most of the plots in this report will have two annotations on each plot. One is a yellow dashed line that corresponds to the management thresholds for Edgartown Great Pond (EGP). The other is a box shaded red, which corresponds to when the variable in question reaches extreme values that cause concern. Occasionally, there will be multiple lines in one plot, and in that case each line is a different color corresponding to a different sampling collection, such as different depths or different years. The title on the graph (on top) will show where the data were collected, and the figure caption (adjacent to the figure) will further explain the graph or image.

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Appendix

Glossary of Water Quality Parameters

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.

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. The GPF management threshold is **15 ppt**, which is the lowest salinity in which eelgrass can survive.

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.

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.

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**.

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.

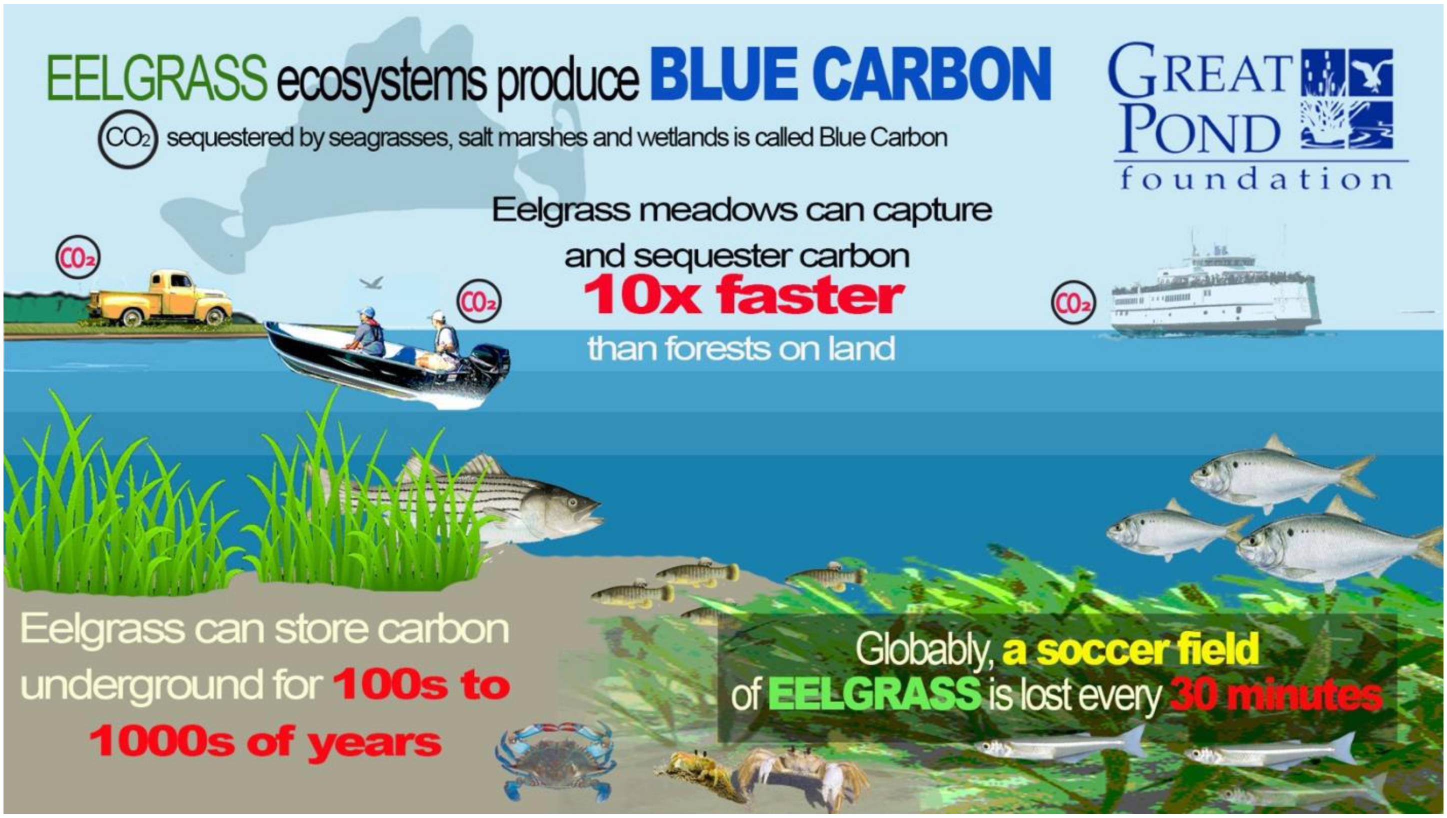
Total Nitrogen (TN): The amount of inorganic and organic nitrogen in the water and the sum of all the different forms of nitrogen. The MEP found that nitrogen was driving impairment in EGP and set the management goal of **0.5 mg/L TN**.

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.

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.

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.

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.



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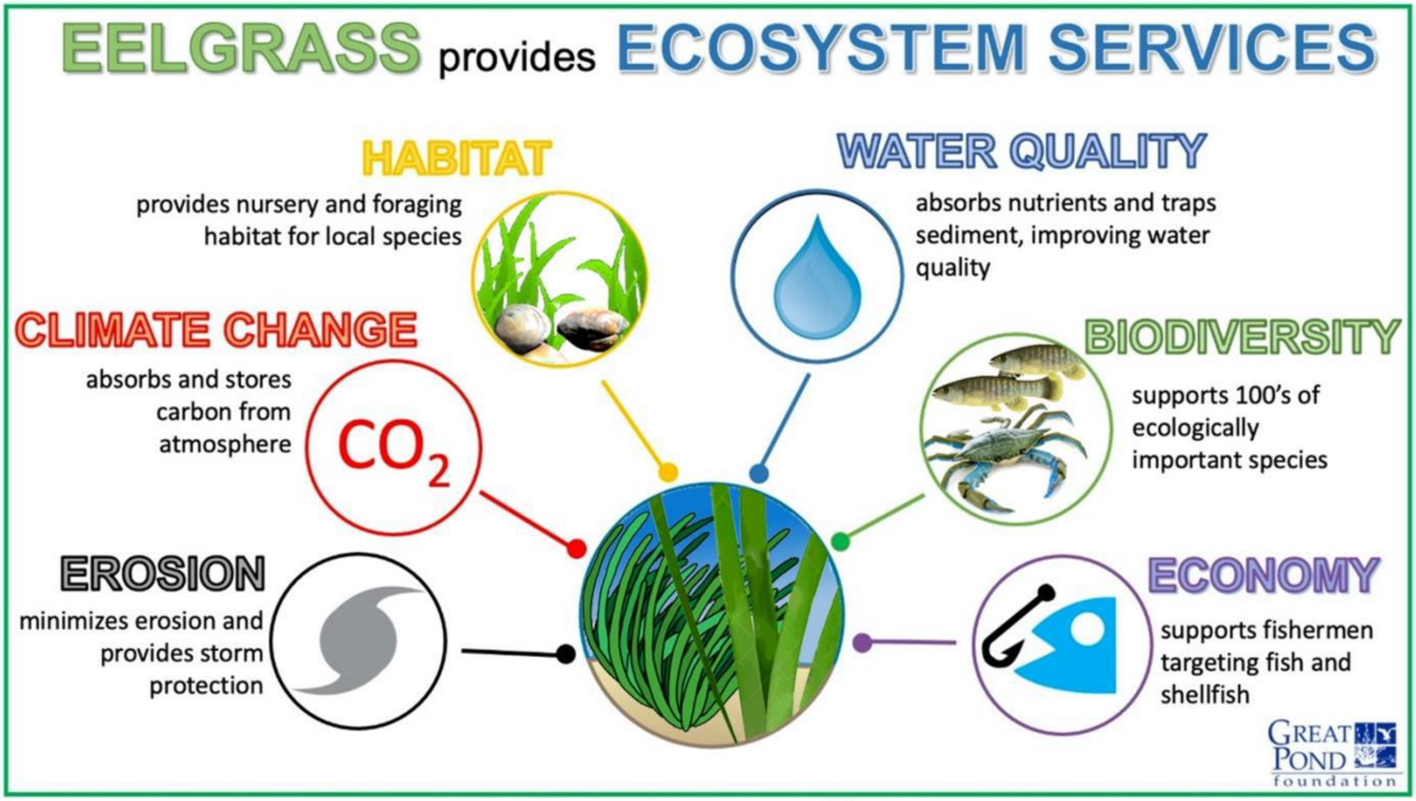

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