Data Tells Encouraging Story for Edgartown Great Pond

Positive trends in Edgartown Great Pond water quality affirm pond management practices

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Great Pond foundation

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After 10 years of careful management, the health of the Edgartown Great Pond appears to be trending in a most positive direction. Based upon Massachusetts Estuary Project (MEP) and EPA standards, Edgartown Great Pond's water quality meets or exceeds the targets for dissolved oxygen, water clarity, and temperature. There is also evidence that Edgartown Great Pond's eelgrass beds, vital to larval shellfish and an indicator of estuary health, have expanded in distribution and health since the 2008 MEP final report. The apparent improvement in Edgartown Great Pond's water quality affirms the effectiveness of the last decade of Pond management.

The buildup of excess nutrients in an estuary can result in harmful algal blooms, poor water clarity, oxygen depletion, and ecosystem devastation. This process is termed eutrophication and is one of the biggest challenges facing all Vineyard estuaries. In 2008 the MEP released a report (Howes et al., 2007) that employed a combination of ecosystem health assessment and modeling to determine the healthy nitrogen load of Edgartown Great Pond (EGP). The MEP determined that EGP's nitrogen load was in excess of ideal and established a reduced target for Total Nitrogen (TN <0.5 mg/L). Nitrogen is the limiting nutrient in EGP, and therefore if levels of nitrogen are decreased, habitat impairment can be reversed, and eutrophication can be controlled (Howes et al, 2007).

Responding to the recommendations of the MEP report for EGP, the non-profit Great Pond Foundation (GPF) raised funds to purchase a dredge for Edgartown Great Pond. The main purpose of dredging in the EGP is to increase the effectiveness of Pond openings to the Atlantic Ocean and the subsequent flushing and refreshing of the Pond with salty oxygenated ocean water. Relocation of the sand that forms a delta in the Pond north of where the barrier beach is cut to the Atlantic Ocean, enables a larger volume of water to be exchanged for a longer period of time. Since 2009, GPF has been operating the dredge between November 1st and March 1st each year. The combination of GPF's winter dredging and carefully timed pond openings 3-4 times per year, as directed by the Edgartown Shellfish Constable, appear to be effective management tools.

During this same time period the Martha's Vineyard Shellfish Group, with the support of the Edgartown Shellfish Department and GPF interns, repopulated EGP with Dermo-resistant oysters that are now increasing in abundance both through management activities and natural spawning events. Oysters feed by filtering out suspended plankton and nutrients from the water column and accumulate nitrogen in their shells and tissues. Each oyster can filter up to 50 gallons of water per day and acts as a natural filter in the estuary. To remove the accumulated nitrogen from the estuary, the oyster must be harvested from the pond. The challenge to this effective and natural nitrogen mitigation cycle is to make sure that the standing brood stock of oysters in the estuary is not overfished and the timing of harvests is in balance with the needs of the ecosystem. Oysters and the sediments around oysters support denitrifying bacteria that can transform harmful nitrogen (nitrate/nitrite) into inert nitrogen gas (N^2); an added environmental advantage (Arfken et al. 2017). In addition to the ecosystem benefits, there is also a substantial recreational and economic value in the shellfish harvest in Edgartown Great Pond (2016 value: $108,183; 2017 value: $107,645; Edgartown Town Reports 2016-2017). The increase in the oyster population, the generally clear water throughout the

Dermo is a disease that decreases the longevity of oysters and was first detected in EGP in 1994. Oysters in EGP have shown a natural resistance to Dermo and are used as genetic stock for other ponds infected with the disease.

summer, and the lack of recent algal blooms provide many qualitative signs that the water quality in Edgartown Great Pond is improving.

Beginning in 2016, Great Pond Foundation increased its commitment to data gathering in the EGP. The Foundation launched a robust year-round water sampling program with a goal of scientifically measuring and quantifying the potential improvement in water quality. One of the critical objectives of this water sampling program was to document the seasonal variation in water quality, and to be able to track trends in the data from year to year. To accomplish that goal required the ability to capture enough data to distinguish between annual variation (temperature, rainfall, cut timing/duration) and trends in Pond health. Great Pond Foundation, with the leadership of its full time Director of Science and Education, and supported by a strong summer intern program, has been collecting data at 10 water stations distributed throughout EGP year-round since July of 2016. Water is sampled throughout the water column from the surface to the bottom and sampling is conducted during all four seasons, weather permitting. Estuarine ecosystems undergo seasonal and biological cycles during the year and GPF has developed a sampling regime with increased frequency and granularity in order to provide greater resolution of these cycles and to document the water quality before and after pond openings. GPF data indicate that the water quality in Edgartown Great Pond has not only improved since the time of the MEP report, but that it consistently meets or exceeds standards for a healthy estuary throughout the year.

Dissolved oxygen (DO), or the amount of oxygen in the water, is a key indicator of ecosystem health. DO is essential to the metabolism of plants and animals in an estuarine ecosystem. The dissolved oxygen standard for healthy estuaries is DO ≥ 6.0 mg/L. Low levels of dissolved oxygen can inhibit the growth of plants and animals and can even lead to death in cases of severe or prolonged oxygen depletion. During GPF's 2016 and 2017 water sampling, DO rarely dropped below this level. At the station closest to the cut (EGP6), the DO in bottom water fell below this ideal value only one time (Figure 1).

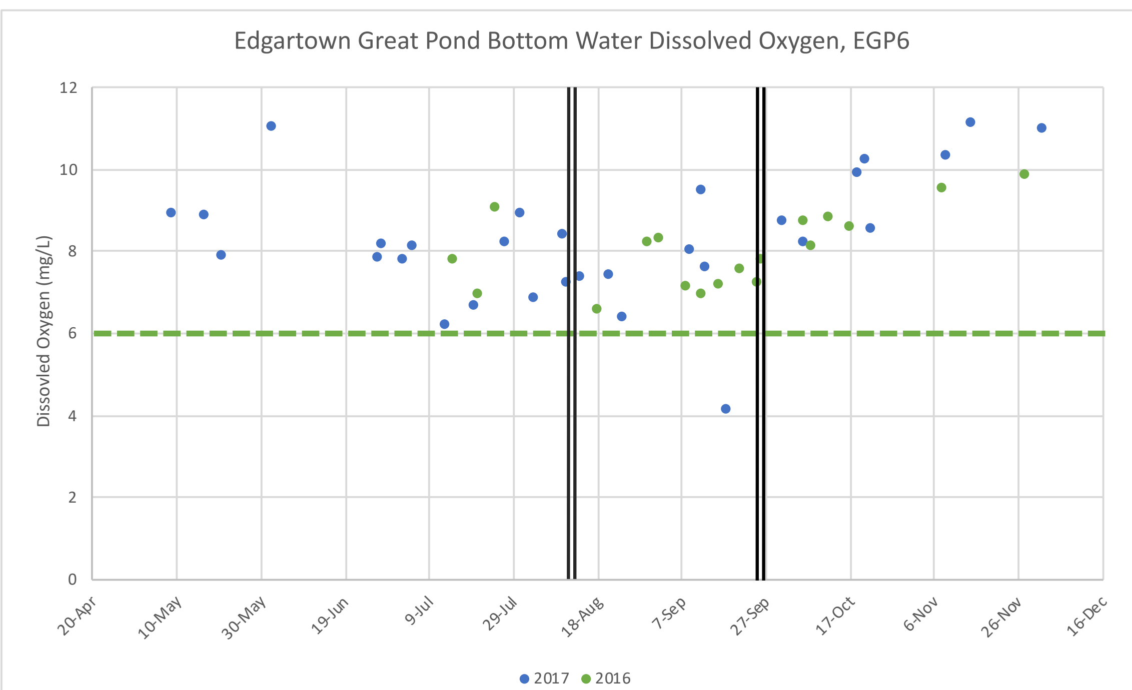

Figure 1: Dissolved Oxygen (DO) levels of bottom water in Edgartown Great Pond at water station EGP6 in 2016 and 2017. The green dashed line indicates the target value of DO = 6 mg/L. Double black lines indicate the time of year DO was measured during the MEP study, see data in Figure 2.

To record bottom water dissolved oxygen levels, the MEP scientists deployed autonomous DO sensors in the late summer of 2002 (Figure 2). They recorded the diurnal DO variation and minimum DO levels. These data from 15 years ago indicate impairment in water quality both because of the six instances of oxygen depletion (DO < 6 mg/L) and the magnitude of the difference between daily high and low DO levels. The larger the daily difference in dissolved oxygen, the higher the level of potential impairment (EPA Water Quality Standards Handbook). The frequency and duration of bottom water dissolved oxygen depletion determines which organisms can survive and therefore has an impact on habitat organization (Howes et al, 2007). By contrast GPF DO data at the same water station (EGP6) in 2017 and 2016 is consistently above the 6.0 mg/L target, with only one exception (Figure 1). Dissolved oxygen values were high and similar patterns were observed at all 10 water stations located throughout EGP that GPF sampled in 2016 and 2017. GPF data indicate that water quality has improved over the last 15 years and that it may be time to reevaluate the impairment status of Edgartown Great Pond.

Edgartown Great Pond Bottom Water Dissolved Oxygen, EGP6

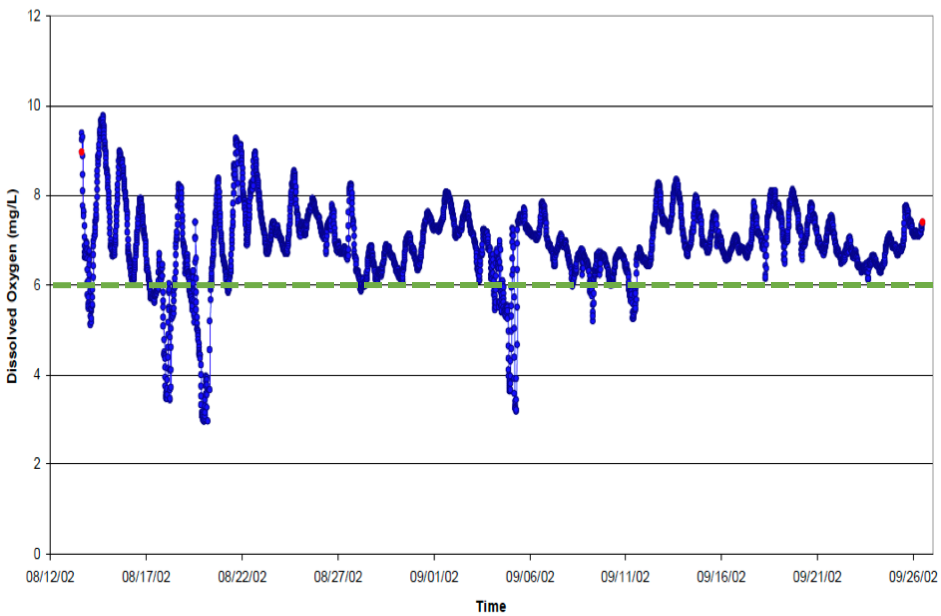

Figure 2: Dissolved Oxygen (DO) levels of bottom water recorded in 2002 from an autonomous data logger at water station EGP6 (West End DO) of Edgartown Great Pond. This figure is from the 2008 MEP report for EGP and is reproduced with permission of the Massachusetts Estuaries Project (collaboration between University of Massachusetts-Dartmouth, School for Marine Science and Technology and the MassDEP). Green dashed line indicates the target value of DO = 6 mg/L.

In addition to meeting and exceeding water quality targets for dissolved oxygen, Edgartown Great Pond stayed below the maximum healthy temperature of 85 °F, as it had a maximum recorded temperature of 83.2 °F for the 2016 and 2017 sampling seasons. Water clarity is another indicator of the health of an estuary. The amount of light that reaches the pond floor determines whether plants can grow on the bottom, as plants need light to photosynthesize. Water clarity is also important because turbid or murky water can indicate algal blooms. A Secchi disk is a 30 cm round dish with contrasting black and white quadrants that is lowered into the water until it disappears. The average of depths at which the Secchi disk disappears and then reappears, is a standard measure of water clarity. During the MEP study, Secchi depths rarely reached the bottom at several stations including EGP6 (Howes et al., 2007). By contrast, GPF water clarity data for 2016 and 2017 demonstrates that Secchi depths reach the bottom without disappearing for the majority of the year (Figures 3 & 4). When the Secchi disk does disappear before reaching the bottom, it is within the ideal range of water clarity for an estuary (1.45-3.0 m Secchi depth) for all but one instance (EPA's Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters).

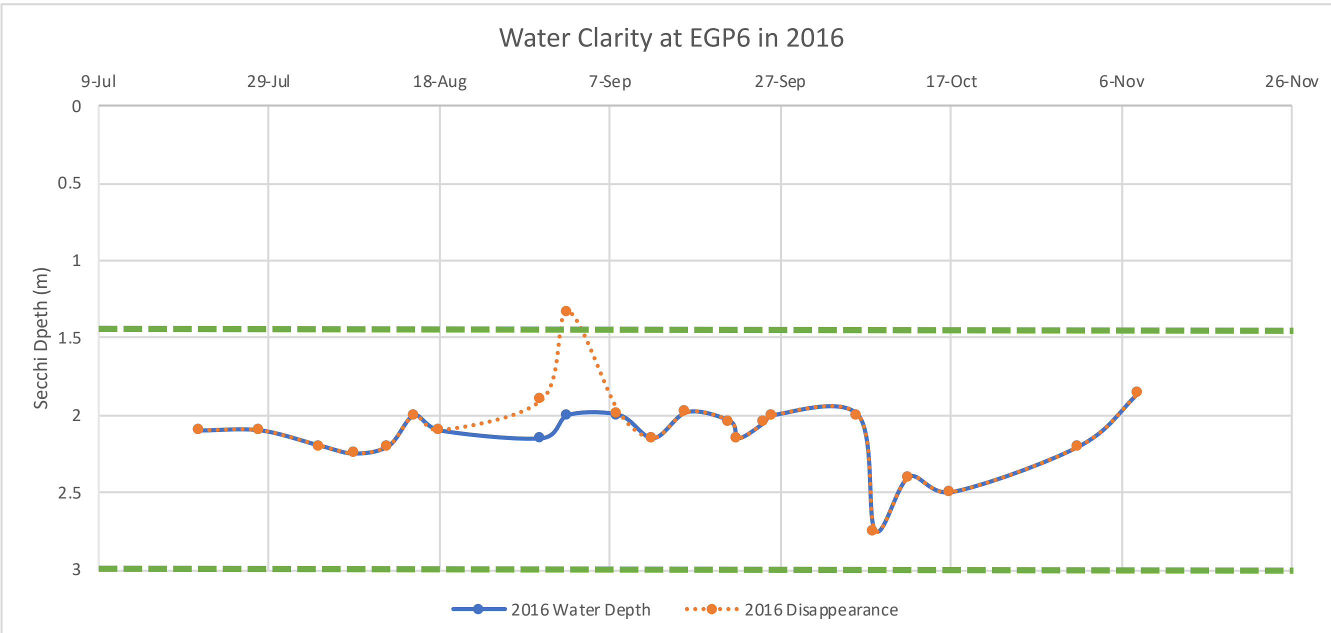

Figure 3: Water clarity as measured by Secchi depth and pond depth in 2016 at EGP6 in Edgartown Great Pond. Ideal water quality is 1.45-3.0 m, as indicated but dashed green line.

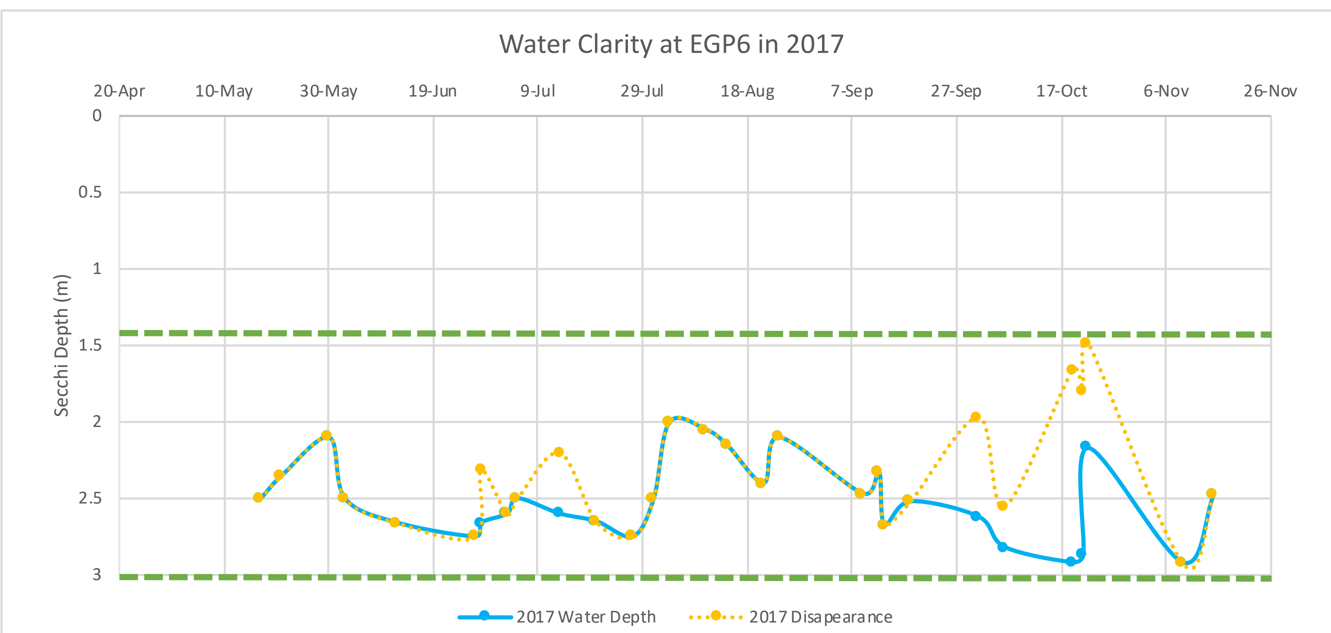

Figure 4: Water clarity as measured by Secchi depth and pond depth in 2016 at EGP6 in Edgartown Great Pond. Ideal water quality is 1.45-3.0 m, as indicated but dashed green line.

Eelgrass, *Zostera marina*, is a native seagrass that serves as habitat for larval fish and shellfish (Thayer et al. 1984), a producer of dissolved oxygen through photosynthesis, and an indicator of the overall health of an estuary (Pe'eri et al. 2016). Over the past 40 years there has been a massive decline in the worldwide distribution and abundance of eelgrass driven by the decreasing water quality in eutrophic and turbid coastal waters (Murphy & Johnson, 2011). Clear water is essential to the survival of eelgrass in estuaries and the depth at which eelgrass can grow is limited by the amount of light that reaches the estuary floor (Thayer et al. 1984). Eelgrass is an essential habitat in island waters and its distribution has been decreasing. The MEP used eelgrass as a "sentinel species for indicating nitrogen over-loading in coastal embayments" (Howes et al., 2007). According to the MEP report for EGP, there is a dearth of historical information about eelgrass in the Pond. In fact, the quantitative assessment of eelgrass habitat is based on a 1951 aerial survey of EGP and a few qualitative field observations from 1997-2006. The MEP report suggests that the decline in eelgrass from 1951 to the time of the report is an anticipated consequence of the excess nitrogen and subsequent high levels of chlorophyll a and low levels of dissolved oxygen (Howes et al., 2007). According to the MEP, restoration efforts to counteract the eutrophic conditions in EGP should concentrate on restoring eelgrass habitat in the lower basin, where there are historical eelgrass records (Howes et al, 2007).

In 2015 the Martha's Vineyard Shellfish Group reported a large increase in the distribution of eelgrass in Edgartown Great Pond (Karney, 2015). Since 2015, eelgrass beds appear to be expanding in distribution and increasing in density (Figure 5). Not only has eelgrass expanded in distribution and density in the lower basin of EGP since 2006, but it is also now present in the upper basin and in several of the northern coves where there are no historical records. In 2017, in conjunction with WHOI biologist Mary Carman, Great Pond Foundation began exploring the density, distribution, and health of eelgrass throughout the Pond with quadrat surveys and linear transects. In order to quantitatively assess the distribution of eelgrass in EGP, GPF has begun working with the Martha's Vineyard Commission (MVC) to use drone surveys to map eelgrass beds. While eelgrass beds worldwide are shrinking, those in EGP appear to be expanding.

Figure 4: Eelgrass beds in Edgartown Great Pond, August 2, 2017. Photos taken with a GoPro camera attached to a Remotely Operated Vehicle (ROV) built by GPF STEM camp students in 2017.

The expanding beds of eelgrass, consistently high levels of dissolved oxygen, and the good water clarity all indicate that the nitrogen levels in Edgartown Great Pond have decreased since the time of the MEP report. The MVC has collected summer water samples following the MEP protocols over the last 15 years. The MVC's samples are collected in July and August, in what the MEP terms the "critical summer period" when the water is warmest, and when historically the water quality has been at its lowest. With the MVC's annual summer sampling, it has been possible to assess the changes in water quality and nitrogen load year over year. This provides a snapshot view of pond health during the critical period and enables pond managers to determine if Total Nitrogen targets are being met or exceeded. MVC data indicate that Total Nitrogen during the critical summer period in EGP in 2016 was TN = 0.523 mg/L, which is just above the MEP target (TN ≤ 0.5 mg/L) and represents a reduction from the TN level of 0.596 mg/L reported in the MEP report on EGP (Howes et al, 2007; MVC Water Quality Data 2016). The increased water quality (DO, water clarity), decreased nitrogen, and expanding eelgrass habitat in Edgartown Great Pond all affirm the improvement of the estuary health over the last decade.

In order to reevaluate the impairment status of Edgartown Great Pond, it is necessary to replicate methods employed by the MEP. To do this, an autonomous deployed sensor would be needed. With a YSI EXO2 Sonde (equipped with dissolved oxygen, total algae, PAR (photosynthetically active radiation), turbidity, salinity, pH, and temperature sensors), the bottom water could be reassessed not only by point sampling, but through the long-term deployment of this auto-recording sensor. In addition to reassessing bottom water health throughout the Pond, a large-scale mapping of eelgrass distribution and density in EGP needs to be completed and replicated annually. This will allow a quantitative assessment of eelgrass expansion or contraction year over year and confirm or refute the restoration of eelgrass habitat; a goal essential to supporting Edgartown Great Pond ecosystem health.

References

Arfken A, Song B, Bowman JS, Piehler M (2017) Denitrification potential of the eastern oyster microbiome using a 16S rRNA gene based metabolic inference approach. PLoS ONE 12(9): e0185071. https://doi.org/10.1371/journal. pone.0185071.

EPA's Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters.

Howes B.L., J. S. Ramsey, R.I. Samimy, D.R. Schlezinger, E.M. Eichner (2007). Linked Watershed-Embayment Model to Determine the Critical Nitrogen Loading Threshold for the Edgartown Great Pond System, Edgartown, Massachusetts. SMAST/MassDEP Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

Karney, Rick. 2015. A Program to Restore the Oyster Populations in Edgartown Great Pond Year 8 Progress Report. Martha's Vineyard Shellfish Group.

Martha's Vineyard Commission (MVC) Water Quality Data; 2016.

Murphy, R., L. Orzetti and W. Johnson. 2011. Plant fact sheet for eelgrass (*Zostera marina*). USDA, Natural Resources Conservation Service, Norman A. Berg National Plant Materials Center. Beltsville, MD 20705.

Pe'eri, S., Morrison, J. R., Short, F., Mathieson, A., & Lippmann, T. (2016). Eelgrass and Macroalgal Mapping to Develop Nutrient Criteria in New Hampshire's Estuaries using Hyperspectral Imagery. *Journal of Coastal Research,76*, 209-218. doi:10.2112/si76-018.

Thayer, G. W., Kensworth, W. J. and Fonseca, M. S. 1984. The ecology of eelgrass meadows of the Atlantic Coast: a community profile. U.S. Fish and Wildlife Service FWS/OBS-84\02.

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