University of Massachusetts Dartmouth
The School for Marine Science and Technology

Technical Memorandum

To: Chris Miller, Town of Brewster Director of Natural Resources

From: Brian Howes, Director, Coastal Systems Program, SMAST, UMassD
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RE: Walkers Pond Light Limitation of SAV Summer 2021

Background:

At the request of the Town of Brewster, the Coastal Systems Program from the School for Marine Science and Technology at UMass-Dartmouth (CSP/SMAST) completed a diagnostic assessment and management plan in 2014 for Walkers Pond, Upper Mill Pond, and Lower Mill Pond.[1] The assessment included extensive complementary and coordinated data collection, including sediment collection and nutrient regeneration assays, continuous measurement of streamflow into and out of the connected ponds, and regular pond water quality measurements. The cumulative review of this data found that all three ponds had impaired water quality conditions due to elevated phosphorus levels. Using this information, CSP/SMAST worked with the Town to present and review management alternatives to address the impairments. Based on these efforts, an adaptive management approach was recommended with regular monitoring and adjustments of management strategies beginning with regular plant harvesting in Walkers Pond to remove phosphorus and an alum application in Upper Mill Pond to reduce sediment phosphorus regeneration.

The Town began the implementation of the management plan by harvesting aquatic plants in Walkers Pond in 2017, but the pond has recently developed less clear water and, as a result, the rooted plants have not been growing back as quickly as expected. The Town has also recently completed the recommended alum treatment on Upper Mill Pond.

At the time of the alum treatment, questions were asked about whether the plant harvesting in Walkers Pond was having the desired effect and whether changes in that pond might limit the benefits of the alum treatment. Based on discussions with Town staff, CSP/SMAST prepared March 2020 scope to evaluate the changes in Walkers Pond and how management strategies might be modified, as well as potential impact of those changes on Upper Mill Pond.

Following further discussions of conditions in Walkers Pond, Town, CSP/SMAST, and TMDL Solutions staff decided to complete some preliminary tasks prior to completing the tasks in in the March 2020 scope. During March 2020, CSP/SMAST and TMDL Solutions staff reviewed available water quality data collected

[1] Eichner, E., B. Howes, D. Schlezinger, and M. Bartlett. 2014. Mill Ponds Management Report: Walkers Pond, Upper Mill Pond, and Lower Mill Pond. Brewster, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 125 pp.

since the data collection for the Management Plan.[2] This review did not find any significant changes from historic levels in the available data, but recommended a series of steps to try to understand why the plants in Walkers Pond were not growing enough to support regular harvesting. One of the least expensive steps/tasks to implement was the installation of light sensors to measure whether sufficient light was available for rooted plants on the bottom of Walkers Pond.

CSP/SMAST staff installed 1 continuous light monitoring device at 65 cm off the pond bottom[3] and a second nearby on upland to measure light on the pond surface. A Photosynthetically Active Radiation (PAR[4]) sensor was installed in 1.05 m water depth in Walkers Pond and recorded light levels every minute from May 1 to Sept. 1, 2020. Light readings were averaged over a 15 minute time period to reduce noise and to enable direct comparison to other contemporaneous data sets. Light profiles of PAR over depth and Secchi disk readings were collected during each instrument check.

Results & Discussion:

Light readings captured throughout the spring and summer showed that PAR was significantly attenuated by water column color and particulates (POC~ 4 mg/L). Maximum light levels rarely reached 800 $\mu E/m^2/s$[5] compared to surface light of 1600-2000 $\mu E/m^2/s$.

Submerged aquatic vegetation or SAV (*i.e.*, rooted plants) requires light for growth and to sustain plant biomass later in the season. Numerous studies have been undertaken to determine the minimum light levels (as PAR) that will support SAV in fresh and estuarine waters. A major review of light requirements for SAV was conducted by the Chesapeake Bay Program for fresh and estuarine waters associated with the Chesapeake Bay.[6] The results of field observations, field light manipulations and modeling strongly supported a threshold light level to sustain SAV in freshwater systems of 13.5 % (11%-14.5%) of surface light. Monitoring indicated that a level of at least ~220 $\mu E/m^2/s$ was typical of plant- colonized areas. These values are similar as found for phytoplankton in Cape Cod Estuaries.[7]

Given that in some years plants can begin to grow in spring and reach mid water – high light conditions, there can be plant colonization in areas with poor bottom light in mid-summer. However, this was not the case in Walker Pond in 2020, as light conditions at the bottom were poor throughout the spring and summer periods. However, previous plant coverage suggest that light levels were sufficient to allow plant growth.

Plants require sustained light intensities above the threshold for net photosynthesis; short periods of adequate light are not sufficient for growth. Light was highly variable in Walkers Pond, ranging from above threshold light levels to very low levels during the daytime each day (Figures 2 & 3). In order to refine the analysis, project reviewed the duration of adequate light levels for plant photosynthesis and growth. Comparing PAR results to a threshold light level range of 200 $\mu E/m^2/s$ to 250 $\mu E/m^2/s$ indicated that there

[2] Eichner, E. and B. Howes. 2020. Walker Pond: Post Management Plan Water Quality Review. TMDL Solutions/SMAST. 13 pp.

[3] Target installation depth was 35 cm off the pond bottom, but hard bottom prevented deployment at this depth.

[4] Photosynthetically Active Radiation = light that is used for photosynthesis.

[5] Microeinsteins per square meter per second.

[6] Carter, V., N. Rybicki, J. Landwehr, M. Naylor. 2000/ Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis; Chapter III: Light Requirements for SAV Survival and Growth, pp. 11-33. Printed by the United States Environmental Protection Agency for the Chesapeake Bay Program.

[7] Taylor, C.D. and B.H. Howes. Effect of sampling frequency on measurements of primary production and oxygen status in nearshore coastal ecosystems. *Mar. Ecol. Progr. Ser.* 108, 193-203.

were only short periods each day, (1.2 to 0.2 hours, respectively) that would support net photosynthesis[8] (Table 1).

Based on the recordings and review, 2020 light levels in Walkers Pond were too low to support SAV recolonization after the prior year's harvest. It is possible that harvesting the SAV resulted in more turbid waters or more colored waters the following year, a condition that will likely diminish in time. At present, with such limited data, it is not possible to determine the cause precisely. However, given that the time since the prior harvest and the water residence time of Walker Pond are similar in magnitude, it is expected that light attenuation has been reduced since PAR was recorded. It is likely that the timing of harvest may need to be shifted or harvesting every other year may be indicated as more data is available.

[8] Net photosynthesis occurs when there is sufficient light to produce more carbon fixation than used by the plant in respiration; for freshwater SAV similar to those in Walkers Pond the minimum light for net photosynthesis is 200-250 $\mu E/m^2/d$.

Figure 1. Location of SMAST light sensor (PAR) in Walkers Pond summer 2020. Top: general location within Walkers Pond, with Slough and Upper Mill Ponds shown for context. Bottom: detail of sensor location. Sensor recorded light at 0.65 m off the pond bottom.

Figure 2. PAR record at 0.65 m depth in Walkers Pond during 2020 spring and summer deployments.

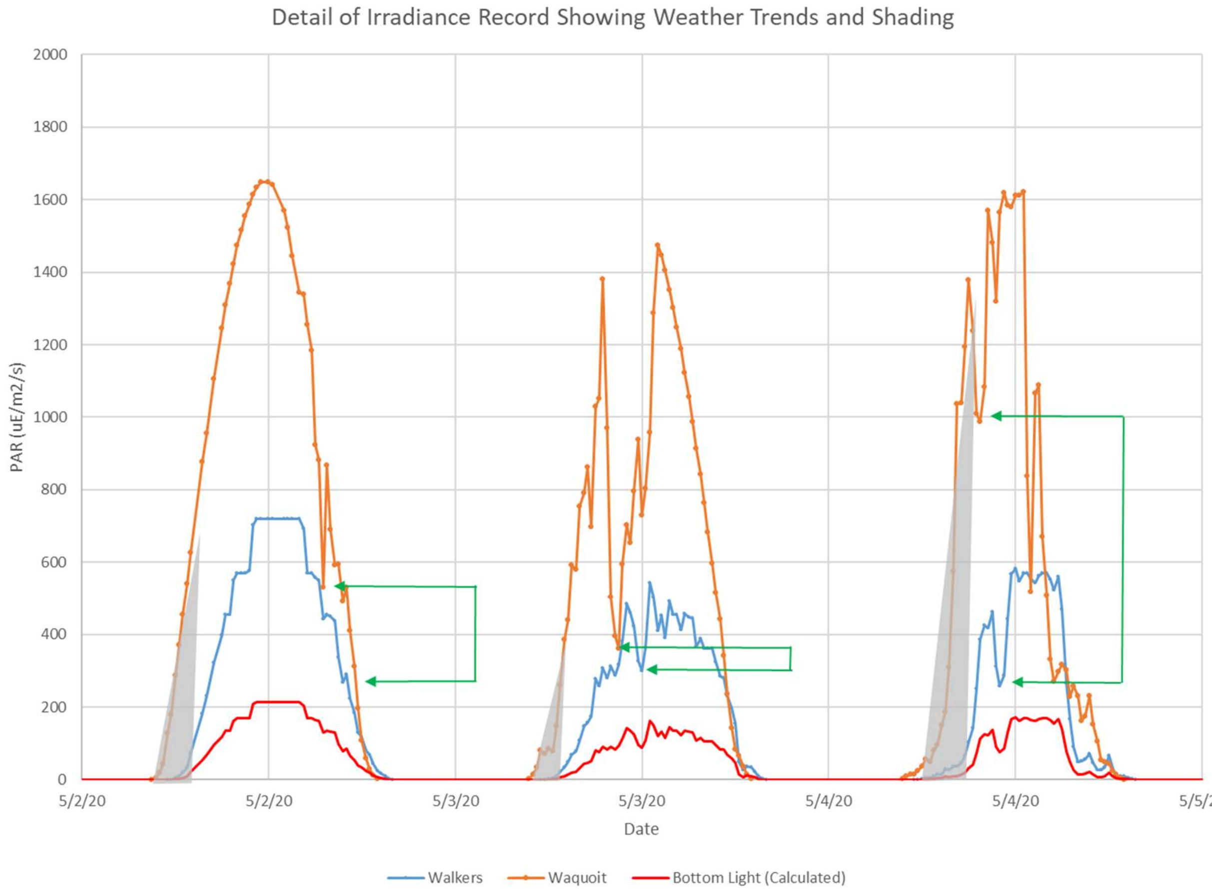

Figure 3. Detail of PAR measurements in Walkers Pond. PAR measurements in Walkers Pond were recorded at 0.65 m off the bottom. A second sensor on upland was altered, so reliable readings were not available. Comparable surface readings at Waquoit Bay (WBNERR) are shown, but are offset slightly by the distance with approximately a 1 hour shift, consistent with storm systems moving across the region. Green arrows show cloud/storm systems moving east to west with a time difference of ~1 hour. Gray Shading indicates periods during the morning when light reaching the underwater meter is reduced by shading from the trees bordering the pond to the east and low angle of the rising sun. There is no shading effect in the evenings when low angle sunlight comes from the west.

Table 1. Estimated Duration of 2020 Bottom PAR above benchmark light thresholds (µE/m²/d) in Walkers Pond. PAR Sensor in Walkers Pond from May 1 to Sept 1 2020 (85.3 days).

Benchmark Values of PAR (µE/m²/s)	>5	>50	>100	>150	>200	>250
Time >PAR benchmark value (days) =	43.9	27.1	17.7	9.3	4.2	0.8
% of daylight hours =	100%	61.6%	40.2%	21.25%	9.6%	1.9%
Average Hours per Day PAR over Benchmark during deployment	12.4	7.6	5.0	2.6	1.2	0.2