A Tale of Two Embayments:

Interactions of Water Clarity, Phytoplankton, Suspended Solids, and SAV Drives Ecosystem Structure

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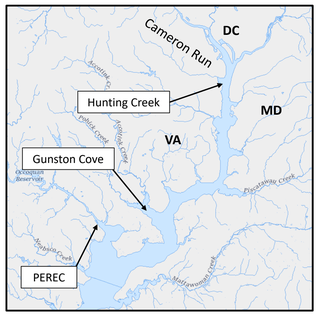
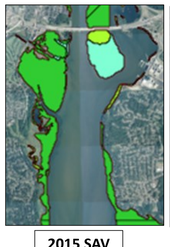
Introduction

Shallow water ecosystems can generally be described as falling into one of two domains: “clear water” systems usually dominated by submersed aquatic vegetation (SAV) and “turbid water” systems dominated by phytoplankton and suspended solids. In multiple systems, transitions between these two types of systems within a given water body has been observed to be abrupt, sometimes due to a significant perturbation and sometimes the culmination of a gradual change in forcing functions. Gunston Cove on the tidal Potomac transitioned from a “turbid water” system to a “clear water” system over a relatively short two year period from 2003-2005 (Jones 2020). This was the culmination of a process which began in the late 1970’s when phosphorus loadings to the tidal Potomac River from municipal wastewater treatment plants began. Gunston Cove represents an example of a gradual process which culminated in an abrupt transition. We present here a case study of Hunting Creek, another embayment on the tidal freshwater Potomac which experienced a significant perturbation which moved it from a “clear water” system to a “turbid water” system in one year.

Study Area



Hunting Creek is an embayment of the tidal freshwater Potomac River located just downstream of the City of Alexandria and the Woodrow Wilson Bridge. Hunting Creek. Waters are shallow the with entire embayment having a depth of 2 m or less at low tide. The mean depth of Hunting Creek is 1.0 m, the surface area is 2.26 km^2, and the mean volume is 2.1 x 10^6 m^3. Beginning in 1985 the entire surface of Hunting Creek was normally covered by a dense macrophyte bed and this was especially true in 2013-2017. Cameron Run provides tributary inflow directly to Hunting Creek.



2015 SAV Coverage (solid mat)

2019 SAV Coverage (bare bottom)

Fig. 1. ***Hunting Creek and Vicinity.***.

Materials and Methods

Beginning in 2013 the Potomac Environmental Research and Education Center (PEREC) at George Mason University has been conducting water quality and aquatic biota studies in Hunting Creek, nearby sites on the tidal Potomac and many of its tributaries. These studies were modeled on the Gunston Cove Ecosystem study and were done in collaboration with Alexandria Renew Enterprises (Alex Renew) which has a major sewage treatment plant on tidal Cameron Run which is the major tributary of Hunting Creek. For the purposes of this paper we will be reporting on data collected at study stations AR2 and AR3 located in the Hunting Creek embayment.

Variables measured in this study include basic field water quality variables like temperature, dissolved oxygen, pH, specific conductance, Secchi disk depth, and light attenuation coefficient. Laboratory measurements included suspended sediment, forms of nitrogen and phosphorus, chloride, alkalinity, and BOD. Algal parameters included chlorophyll a and pheophytin as well as species counts of phytoplankton. SAV mapping was conducted by PEREC personnel in late summer and we also used VIMS SAV annual aerial survey data (VIMS ref). Zooplankton, benthos, and fish were also sampled, but will not be reported here. USGS daily average flow data was obtained or Station 01653000, Cameron Run at Eisenhower Ave. In the following graphs, the term “PRE” will be applied to the data from 2013-2017, while the term “POST” will indicate period 2018-2022 when SAV had disappeared.

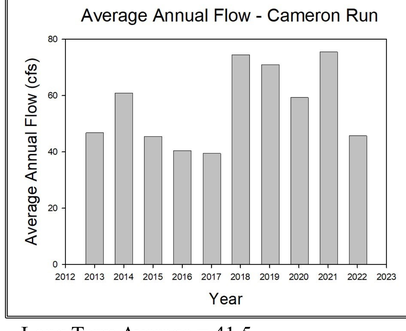
The latest annual report of this study is available on the PEREC website (see Citations).

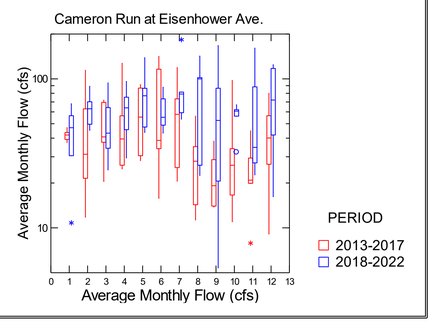
Results

Flow Data

Annual average stream flow data for Cameron at Eisenhower Avenue showed that only 2014 had a higher annual average stream flow than any of the years in the period 2018 period. When monthly patterns were examined, the median flow by month in the PRE period was less than that of the POST period. This effect was found in all months, but was especially pronounced in August and September.

Note that 2018 and 2021 had the highest annual average river flow. In addition, 3 months in 2018 had the highest average flow of the 10 year period: May, July, and September.





Long Term Average = 41.5

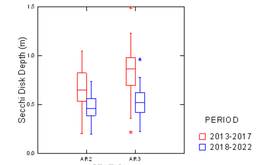
Results

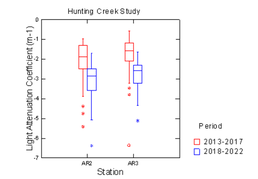
Water Quality Parameters

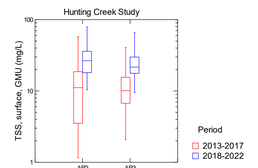
Water Transparency is a very important factor in determining if SAV can maintain a presence in a particular area. In this study we measured both Secchi Disk depth (Z_{SD}) and Light Attenuation Coefficient (k) at two sites in the Hunting Creek embayment: AR2 and AR3. At both stations, both Z_{SD} and k were substantially lower in the POST period than in the PRE period indicating decreased light availability in the absence of SAV.

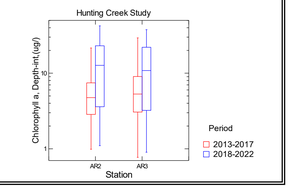
Light availability is determined by the concentration of both inorganic particles and phytoplanktonic algae in the water. Particles can be measured by total suspended solids (TSS) and algae by chlorophyll *a* (Chl*a*). The observed patterns in both of those variables at both stations between the two periods indicated that both were significantly elevated in the POST period as compared with the PRE period. These patterns were even more pronounced with the comparisons were made during the summer.

A multiple regression was conducted to determine the relative contribution of TSS and Chl*a* to the observed decrease in light transparency. These results found that TSS was a much better predictor of light attenuation than Chl*a*.









Conclusions

In summary, a dramatic shift in ecosystem structure occurred in Hunting Creek in 2018 when SAV disappeared from the system. This disappearance was accompanied by a major shift in light availability attributable to TSS and Chl*a*. The abrupt disappearance in SAV may have been due in some part to scouring and physical uprooting of these plants by the record tributary flow in 2018. Regardless of what initiated it, the impact has been persistent such that as of 2023 SAV coverage is still nonexistent in Hunting Creek and the system now has entered the “turbid water” phase with low transparency and phytoplankton as the dominant primary producer.

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Citations

Jones, R.C. 2020. Recovery of a tidal freshwater embayment from eutrophication: a multidecadal study. Estuaries and Coasts 43: 1318-1334.

Hunting Creek Report – 2022. https://perec.science.gmu.edu/wp-content/uploads/2023/07/HC-2022-FINAL-REVISED-REPORT-29June2023-2.pdf

VIMS SAV data: https://mobjack.vims.edu/sav/savwabmap/