2019 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive summary

Masonville Cove, a small inlet of the upper tidal Patapsco River, figures in local Baltimore lore as a natural respite from the rigors of early 20th century city life. However, as the Patapsco River was heavily impacted by pollution from centuries of being a center of commerce and population, so too was Masonville Cove. In 2007, the Maryland Port Administration received a permit to build a dredged material containment facility at the Masonville Marine Terminal, adjacent to Masonville Cove. As part of the mitigation agreement for this project, the Maryland Department of Natural Resources (DNR) deployed a continuous water quality monitor in the summer of 2009, ahead of the construction of the dredged material containment facility. Since 2009, DNR has continued to deploy a monitor during most of the year, although it has been removed in the winter in some years due to icing conditions. In continuation of this project, a water quality monitor was deployed off the Masonville Cove pier during 2019.

Water quality conditions in Masonville Cove during 2019, as in the rest of the Chesapeake Bay watershed, were influenced by meteorological events. Following the wettest year on record in 2018, 2019 was dryer than normal overall, but was very wet during the first half of the year. The runoff during this wet period led to degraded water clarity in 2019 as compared to prior years. For the second consecutive year, chlorophyll concentrations were generally lower than the prior years of monitoring. These lower algal concentrations may be related to the improved dissolved oxygen conditions observed in 2019.

All 2019 continuous monitoring data, as well as data from previous years, are available on the DNR "Eyes on the Bay" website (http://eyesonthebay.dnr.maryland.gov/contmon/ContMon.cfm). Data from grab samples are available through the Chesapeake Bay Program's Data Hub (https://www.chesapeakebay.net/what/data). The most recent seven days of water quality data can also be viewed on the "Eyes on the Bay" Masonville Cove webpage (http://eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm). Data collected in 2019 at the time of each instrument replacement (pigments, suspended solids, Secchi disk depth and ambient water quality data) are also available for download via the following link: http://eyesonthebay.dnr.maryland.gov/contmon/GetConMonDataHub_StationTable.cfm?station=XIE4742&DataHubID=1930&startdate=1-1-2019&enddate=12-31-2019.

Introduction

In 2007, the Maryland Port Administration (MPA) submitted plans to the United States Army Corps of Engineers (USACE) to construct a Dredged Material Containment Facility (DMCF) in the vicinity of the Masonville Marine Terminal (Figure 1). The terminal, located on the upper Patapsco River in Baltimore, is a major port for the automotive industry. The design for the DMCF uses sand and clay dikes to contain material dredged from the navigation channels in Baltimore Harbor. The same year, an environmental impact study submitted to USACE suggested mitigation for the project. Mitigation was deemed necessary as the DMCF was to fill 130 acres of tidal open water, cover 10 acres of upland habitat and disturb 1 acre of vegetated wetland and 0.38 acres of submerged aquatic vegetation (SAV).

In 2019, as continuation of the mitigation plan implemented in 2009, the Resource Assessment Service of the Maryland Department of Natural Resources (DNR) monitored water quality in Masonville Cove adjacent to the DMCF site. DNR deployed a continuous water quality monitor that collected data every 15 minutes on a suite of water quality parameters, including dissolved oxygen, salinity, temperature, turbidity, pH and chlorophyll. Data from this monitor were telemetered to the DNR website "Eyes on the Bay" (eyesonthebay.net) and displayed in near real-time. DNR personnel visited the station every two to four weeks to replace the meters and to collect water samples for analyses of total suspended solids, chlorophyll *a* and pheophytin concentrations. The continuous monitoring site at Masonville Cove was one of three continuous monitoring stations located in the upper Patapsco in 2019. The other two sites were deployed adjacent to the National Aquarium in the Baltimore Harbor.

Description of continuous monitoring

In 2019, a data collection device known as a sonde was attached to a piling on the Masonville Cove pier (39.2447°, -76.5972°) with its instrumentation deployed 1 meter below the water surface (see Figure 1 for station location). This location is approximately one-tenth of a mile west of the deployment location used before 2013 (Figure 1). The location change was made so that DNR field personnel would be able to access the site during winter months, which allows the monitor to be deployed year-round. Prior to 2013, the site was only accessible by boat so the monitor needed to be removed during the winter months when icing at the boat ramp precluded access. The data sonde deployed in Masonville Cove was a YSI™ 6600 V2 (Yellow Springs Instruments, Yellow Springs, Ohio), which housed several water quality sensors (Figure 2). The water quality indicator data collected by each sensor are explained in greater detail in the following section. The sonde collected a reading from each sensor simultaneously every 15 minutes for the duration of its deployment. These readings were stored in the sonde's data memory and sent, by attached cellular telemetry equipment, to DNR headquarters in Annapolis. There, the data were posted on DNR's "Eyes on the Bay" website (eyesonthebay.net) for easy public access. This website enables the public to access near real-time water quality data for numerous locations throughout Maryland. The data are called "near real-time" because there is a lag of approximately 30-minutes to one hour between the time that the sonde collects the data and the time that the data are posted on the website. A page specific to Masonville Cove on the "Eyes on the Bay" website also displays charts and data from the most recent seven days. This page can be found at: eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm.

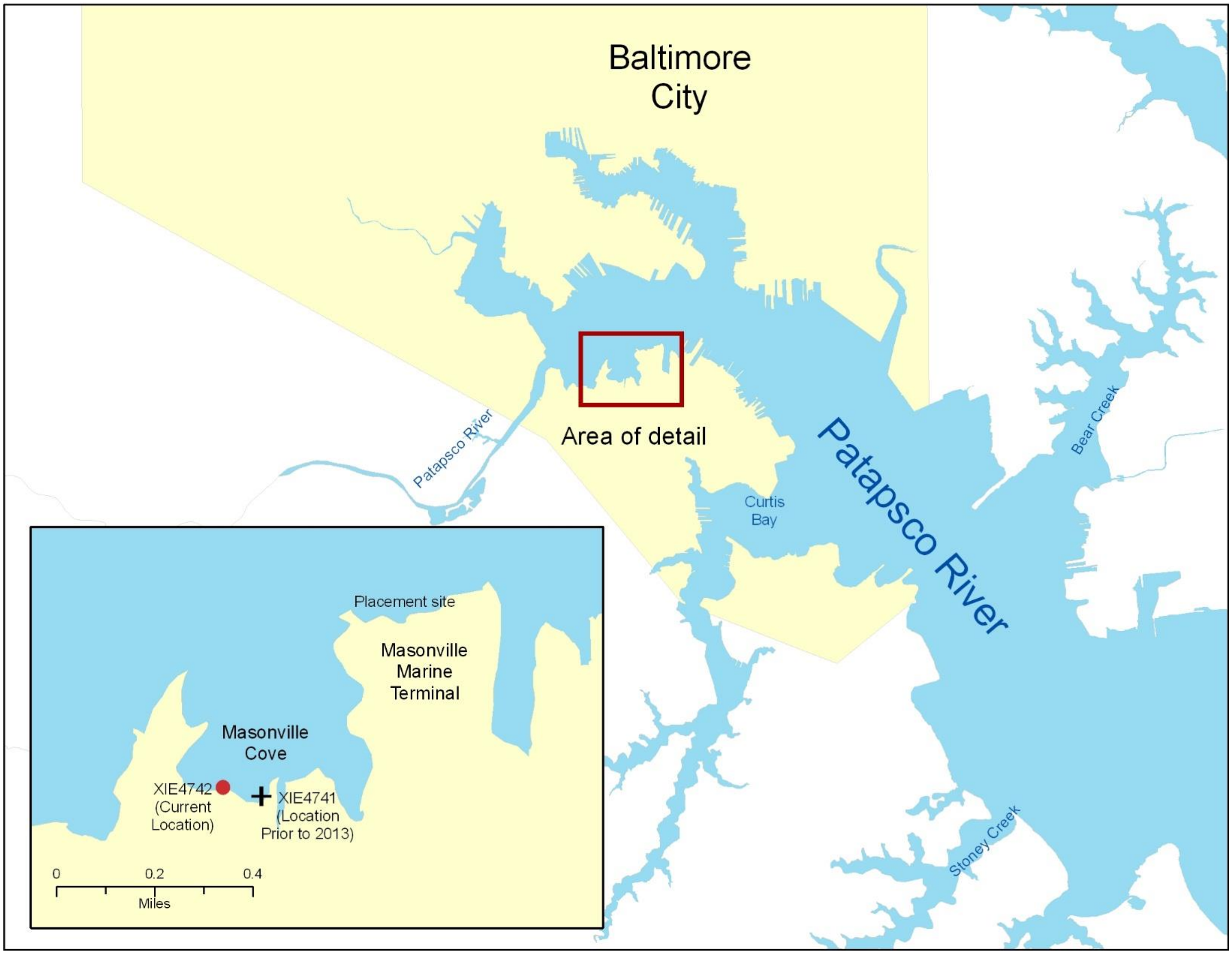

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2019 continuous monitor location within the cove, the location of the monitor prior to 2013 and the approximate site for dredged material placement.

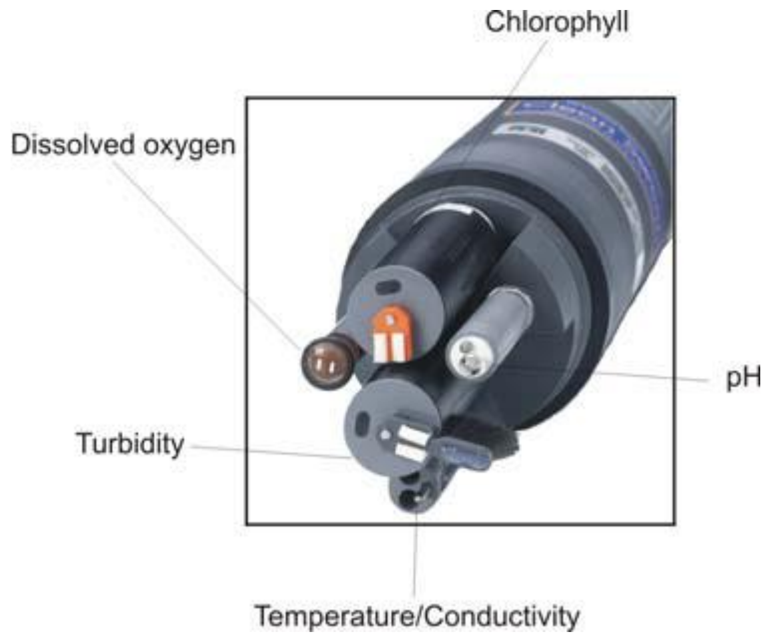

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

Continuous monitoring parameters

The continuous monitor at Masonville Cove, like all continuous monitors in the DNR Shallow Water Monitoring Program, collect data on six water quality parameters:

1. Dissolved oxygen (DO): Fish and other aquatic life require DO to survive. Maryland state water quality criteria require a minimum DO concentration of 5 milligrams per liter (mg/L) (COMAR 1995). This threshold is necessary for the survival of many fish and shellfish species, including blue crabs (*Callinectes sapidus*) and striped bass (*Morone saxitilis*).
2. Salinity: Salinity, or salt concentration, is calculated automatically by the continuous monitoring sonde from conductivity and temperature readings. Salinity in the Patapsco River comes from the Chesapeake Bay. Therefore, areas closer to the Bay have higher salinities, except perhaps during large freshwater releases from the Conowingo Dam on the Susquehanna River. During periods of low precipitation and river flow, salinity increases as salty water intrudes further up the river. During wetter periods, salinity decreases. Salinity also cycles in relation to tides, increasing during flood tides and decreasing during ebb tides. Salinity levels are important to aquatic organisms, as some organisms are adapted to live only in brackish or salt water, while others require fresh water.
3. Water temperature: Water temperature is another variable affecting suitability of waterways for aquatic organisms. Many aquatic organisms can tolerate gradual temperature changes associated with changing seasons, but sudden changes can cause stress. Higher water temperatures cause more dissolved oxygen to come out of solution and enter the air, decreasing the amount available to fish and other aquatic organisms.
4. pH: The acidity of water is indicated by pH. A neutral pH is 7; lower values indicate more acidity, while higher numbers indicate more alkaline conditions. pH is affected by salinity (higher salinities tend to buffer pH in the 7-8 range) and algal blooms (large algal blooms can raise the pH over 8 in low salinity waters).

5. Turbidity: Turbidity is a measure of water clarity. Events that stir up sediment or cause runoff, such as storms, will increase turbidity. Dense algal blooms will also cause higher turbidities. Relatively clear water (low turbidity) is required for growth and survival of submerged aquatic vegetation (SAV).
6. Chlorophyll: Chlorophyll concentration is a surrogate measure of the amount of algae in the water. Chlorophyll is the main photopigment responsible for photosynthesis, the process by which sunlight is converted into food energy. Chlorophyll concentrations are calculated from fluorescence values collected by the sensors. One downside to this method is that certain species of phytoplankton, such as cyanobacteria or blue-green algae, fluoresce outside the detection range of the chlorophyll fluorescence sensor.

Calibration of continuous monitors and collection of laboratory water samples

Pigments and suspended solids data were obtained by DNR staff during deployment and replacement of continuous monitoring data sondes. Discrete whole water samples were collected to measure chlorophyll *a*, pheophytin and total suspended solids. Data sondes were removed and replaced with freshly calibrated instruments on a biweekly basis between April and October and once a month between November and March. At the time of each instrument replacement, Secchi disk depth was recorded for use in water clarity determination and water column profiles were taken. During profiles, an instrument was lowered into the water and collected readings for depth, water temperature, pH, dissolved oxygen and salinity.

Masonville Cove continuous monitor deployment

In 2019, a continuous monitor at Masonville Cove was deployed the entire year. Data sondes collected 33,827 data records and 17 calibration samples were collected and analyzed in 2019. Generally, calibration samples are collected when sondes are changed out every two weeks between April and October and every four weeks between November and March. However, DNR field personnel were unable to service the station between April 15th and June 13th. During this time, the United States Fish and Wildlife Service enforced a no entry policy into areas surrounding the monitoring site due to a pair of nesting eagles. A malfunction to the water quality monitoring sonde precluded data collection between October 18th and October 31st. Additional gaps seen in the data are where questionable data were removed for quality assurance purposes. Automated telemetry generally operated when deployed, but there were times when telemetry did not work properly, which led to gaps in near real-time web presentation of the data. Telemetry issues did not, however, impede the sonde from collecting data.

On December 10th, DNR personnel installed a new data logger and telemetry unit at the Masonville Cove monitoring station. This system replaced a unit that contained outdated hardware no longer supported by cellular carriers.

2019 Precipitation and Discharge Events

Precipitation increases runoff into waterways, which can lead to a higher input of nutrients that fuel algal blooms, decrease water clarity and suppress SAV growth. Although beyond the scope of sampling for this report, precipitation has also been tied to increased loads of contaminants from urban and industrial centers in and around Baltimore (Leffler and Greer 2001).

Following the wettest year on record in 2018, annual precipitation for 2019 at Baltimore Washington International (BWI) Thurgood Marshall Airport was 3.75 inches below the 30-year average (Figure 3). The wet pattern from 2018 continued for the first three months of 2019, before total precipitation fell below monthly averages in six of the last nine months of the year. September was the driest month of the year as measurable precipitation fell on only three days of that month, and total monthly precipitation was 0.16 inches. October was the wettest month of the year with 6.21 inches of precipitation. The largest single precipitation event of 2019 occurred on March 21st as 1.74 inches of rain fell that day in Central Maryland. This heavy rain event was associated with multiple reported sanitary sewer overflows in the Patapsco River watershed that discharged over 37 million gallons of untreated, diluted wastewater.

Daily mean discharge at the USGS gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2019 (Figure 4). Gage data show numerous spikes throughout 2019, which are indicative of the precipitation events that affected the region during the year. Even with the dryer than average year, flows were generally above the daily historic median during most of the year, except for September into October, which was the driest period of the year (Figure 3). The largest flows of the year occurred during heavy rains in January and March. January flows were approximately 25-times greater than the daily historic median, while March flows were 15-times greater.

Details of the sanitary sewer overflows described in this section can be found through the Maryland Reported Sewer Overflow Database:
https://mde.state.md.us/programs/water/Compliance/Pages/ReportedSewerOverflow.aspx#.

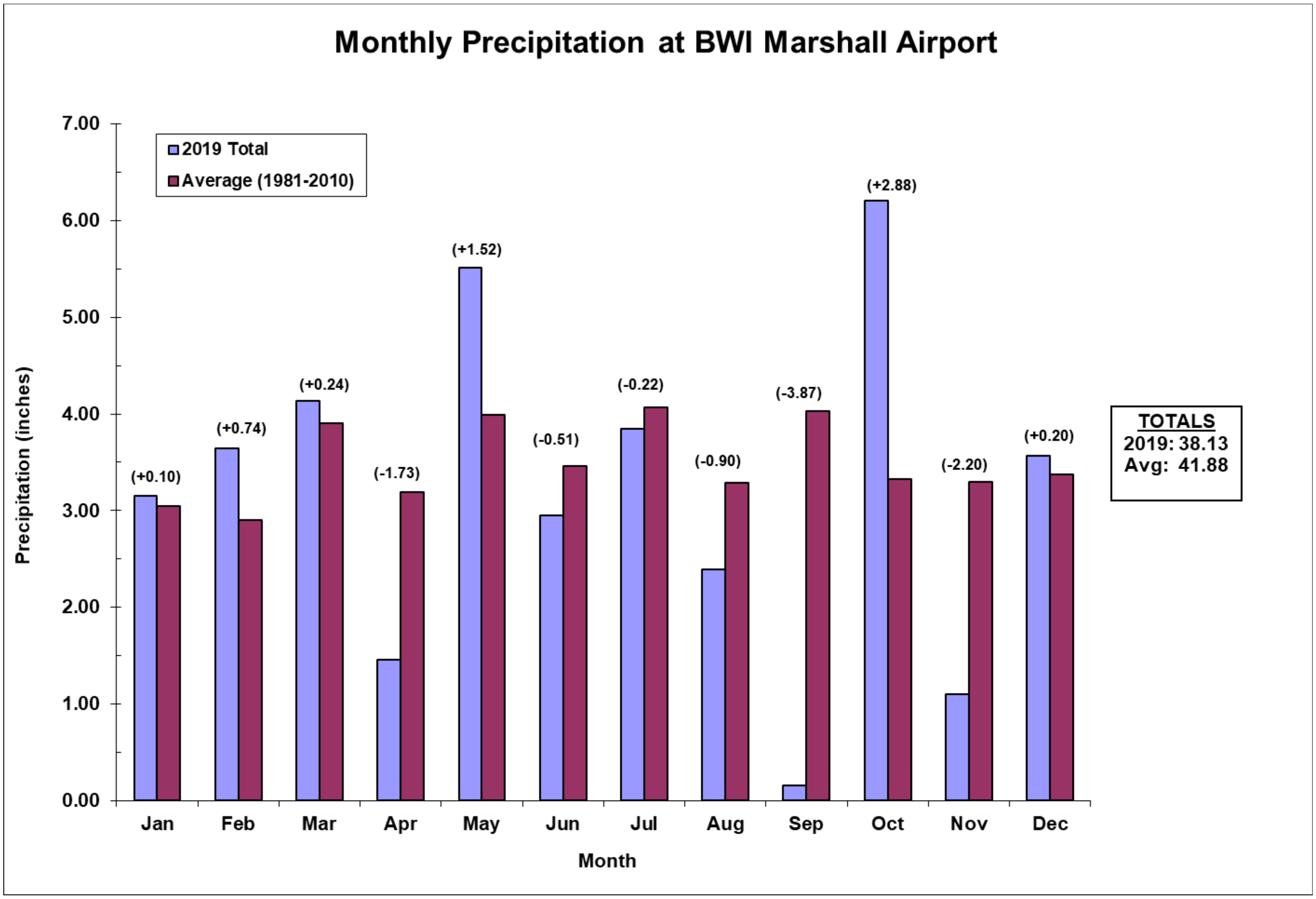

Figure 3. Total 2019 monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages. Data source: National Weather Service (weather.gov/media/lwx/climate/bwiprecip.pdf).

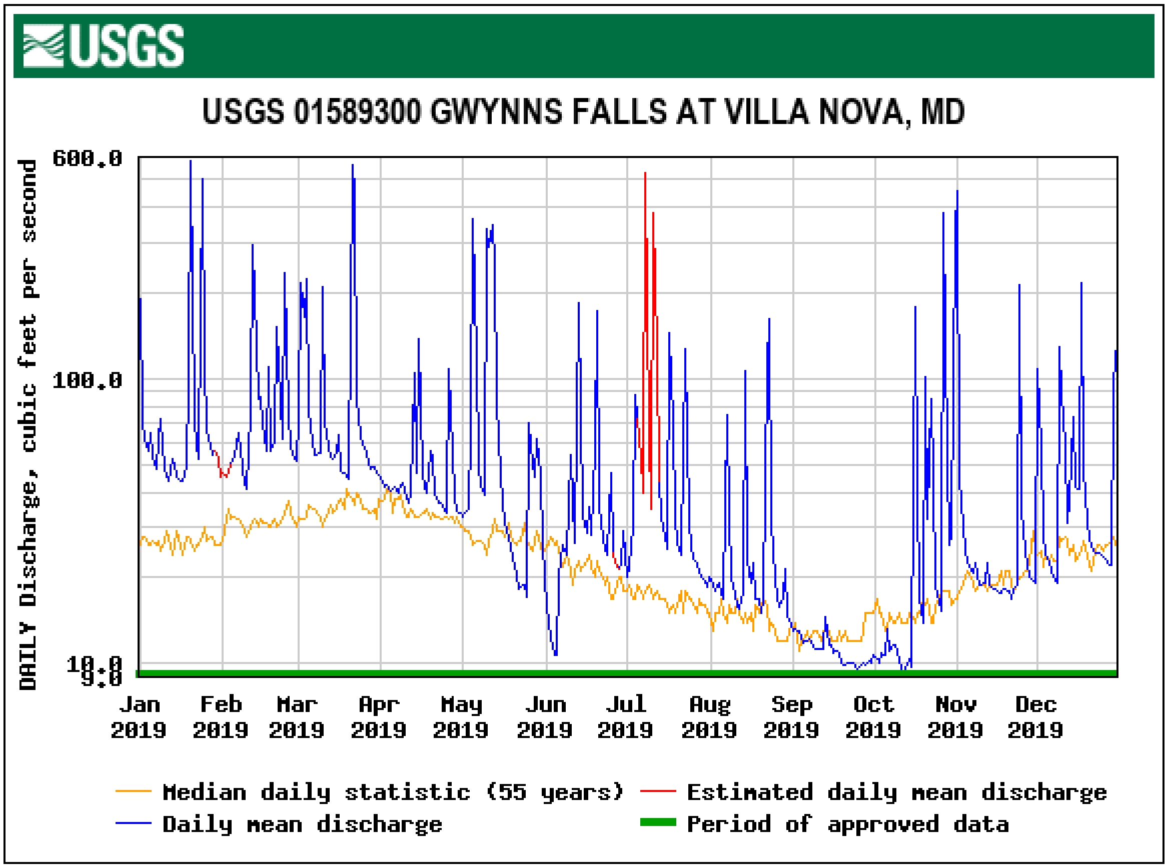

Figure 4. 2019 daily discharge in cubic feet per second measured at a USGS gaging station northwest of Masonville Cove. Graph courtesy of the United States Geological Survey (waterdata.usgs.gov/nwis/dv/?site_no=01589300).

<u>2019 Continuous Monitoring Data</u>

Water temperature

Water temperature at Masonville Cove rose predictably during the first seven months of 2019 as air temperatures increased (Figure 5). Temperatures peaked at 32°C (90° F) in late July and generally remained at or near 30°C into late August. Heavy rains in late August led to a 7°C (12° F) drop that began a decline in water temperature, as air temperatures dropped, through much of the rest of the year. Variability in the plots in Figure 5 was most likely a result of diel variation in temperature (warming temperatures during the day and cooling temperatures during the night).

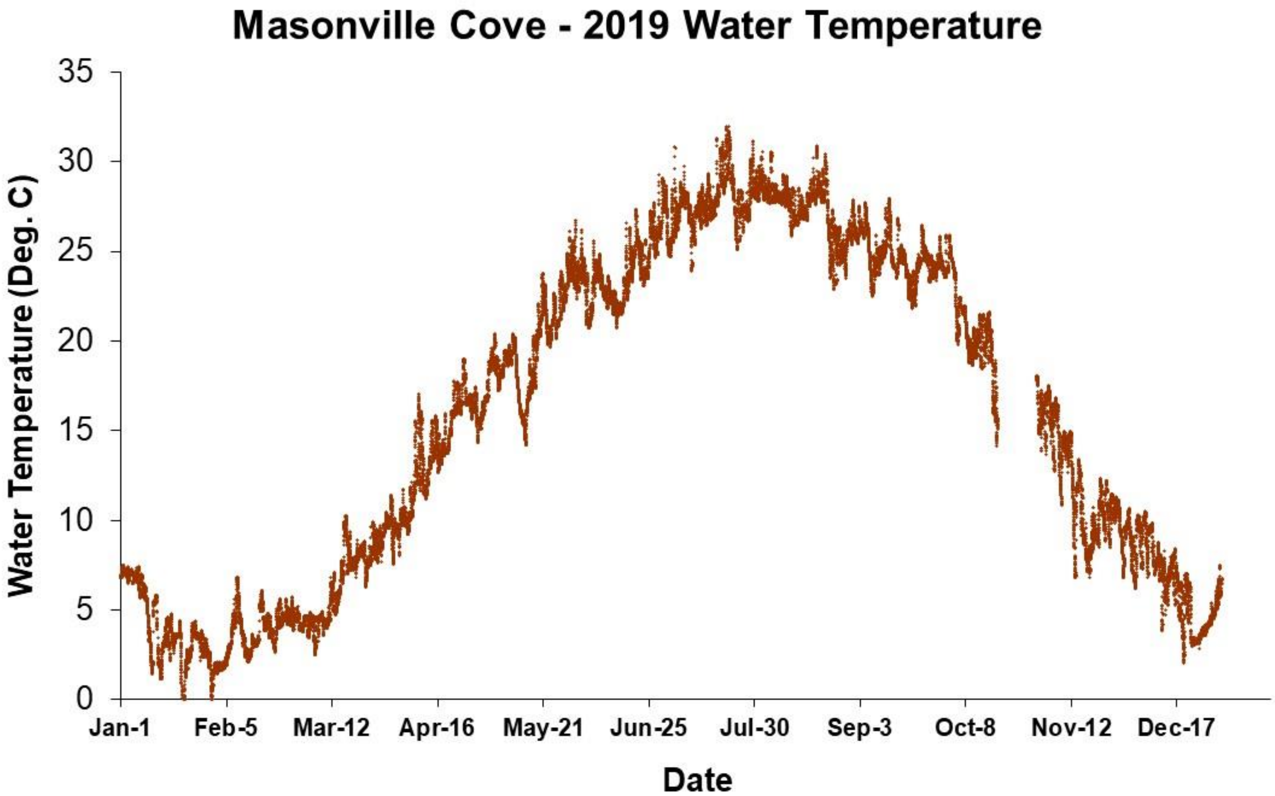

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2019.

Salinity

Salinity tends to vary with precipitation and streamflow. The general annual trend in salinity that has been observed at Masonville Cove since monitoring began in 2009 is higher values in late winter and early spring, a drop in readings during the wetter summer months, and a rise in values again in the late fall and early winter. During the first three months of 2019, however, salinity values were kept depressed (Figure 6) by the higher than normal rainfall. Salinity continued to drop into mid- to late spring to its lowest levels of the year in mid-May (Figure 6). Salinity then rose throughout the dryer than normal summer (Figure 3) to over 12 parts per thousand (ppt) in early October (Figure 6). Values continued to rise and peaked at over 16 ppt in early December, before declining again during a wet end of the year.

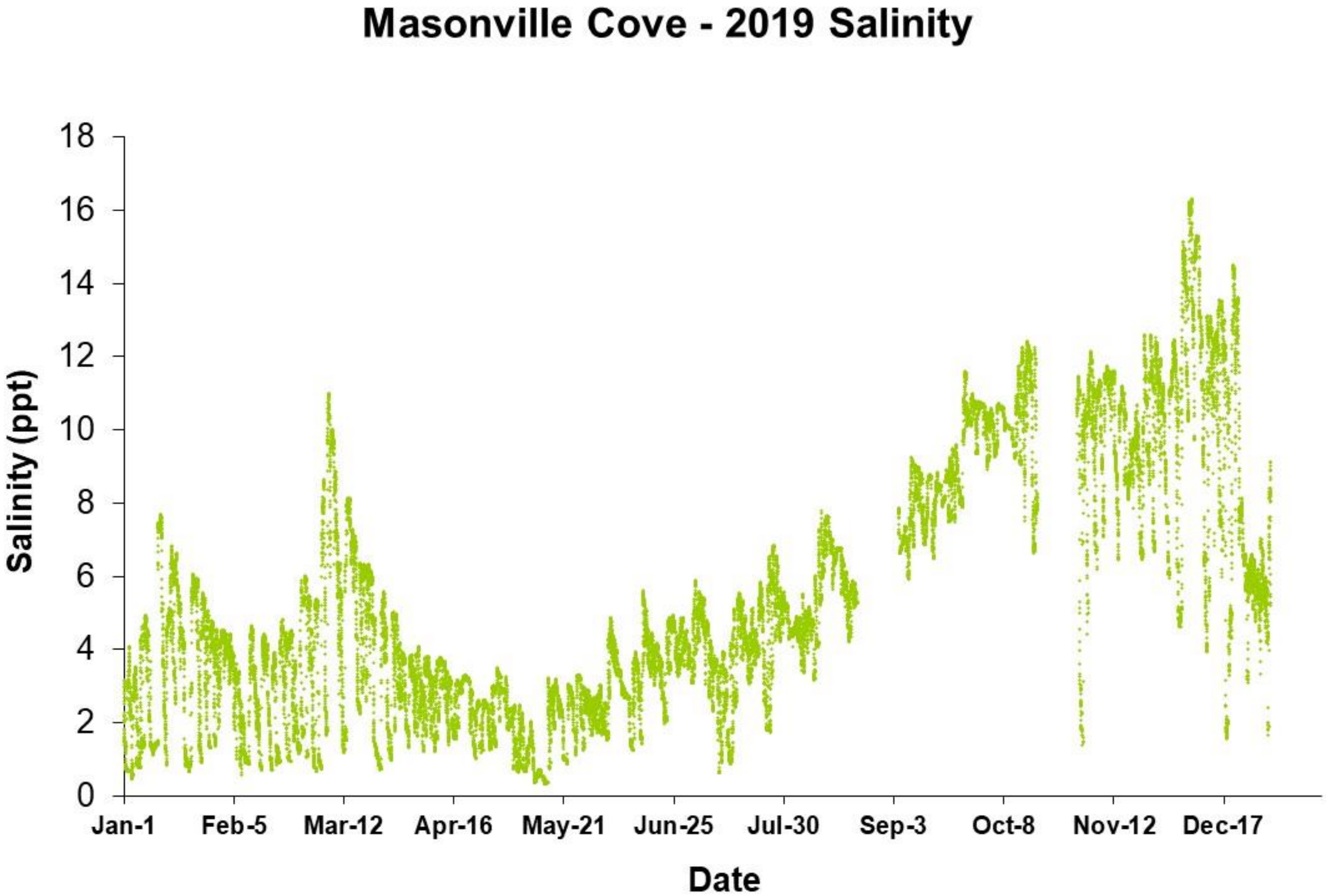

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2019.

Dissolved oxygen

Dissolved oxygen (DO) values remained high through most of the spring and early summer in 2019, but then dropped in late May and early June (Figure 7). Oxygen levels remained suppressed through the summer and into October, and exhibited large swings in concentrations during this time with a significant number of readings < 5 mg/L. Prolonged periods of low DO concentrations can stress and be detrimental to the survival of juvenile fish and other aquatic animals (U.S. Environmental Protection Agency, 2003). Oxygen readings increased again through the remainder of the year. The summer decrease and fall/winter increase were expected since warmer water carries less dissolved oxygen, while cooler water can hold more. However, the large daily swings seen in DO levels between late May and early October may be indicative of algal bloom conditions in Masonville Cove during this time period (Figure 8).

The highest DO concentrations of the year, which approached and exceeded 20 mg/L, occurred during algal blooms observed in January/February, and again in December (Figure 8). Oxygen concentrations can become super-saturated (greater than 100% saturation) and peak during the day during such conditions when algal cells are photosynthesizing and producing large amounts of oxygen. However, DO can drop to very low levels at night when photosynthesis ceases and oxygen is consumed through cellular respiration. Furthermore, decreases in chlorophyll levels can signal the death and decomposition of algal blooms and are often accompanied by a drop in DO levels. The decomposition process can consume significant amounts of oxygen in the water and can lead to conditions harmful to aquatic organisms. For example, decreases in DO levels to low concentrations at the Masonville Cove water quality monitor coincided with large drops in chlorophyll concentrations (Figure 8) on June 24th (1.1 mg/L), July 1st (0.87 mg/L), August 30th (0.76 mg/L), and October 15th (2.28 mg/L).

As part of the 1987 Chesapeake Bay Agreement, the signatories agreed "to provide for the restoration and protection of living resources, their habitats and ecological relationships." Further, the Chesapeake Executive Council (CEC) committed to "develop and adopt guidelines for the protection of water quality and habitat conditions necessary to support the living resources found in the Chesapeake Bay system, and to use these guidelines in the implementation of water quality and habitat protection programs." Because prolonged periods of low DO concentrations can stress and be detrimental to the survival of juvenile fish and other aquatic animals (U.S. Environmental Protection Agency, 2003), a document was produced by the Chesapeake Bay Program outlining dissolved oxygen thresholds for various living resources (Jordan et al. 1992). The State of Maryland adopted these dissolved oxygen thresholds as standards in 1995 (COMAR 1995). For shallow water habitats, the DO criteria are a 30-day average of 5 mg/L and an instantaneous minimum of 3.2 mg/L. Table 1 shows the percentage of time the Masonville Cove DO data fell below these criteria values between April and September, which is generally the time of year that DO values are the lowest due to warmer waters. In 2019, DO failure rates increased slightly following a two year improvement (Table 1), but were still among the lowest failure rates since monitoring began at Masonville Cover in 2009. Concentrations were below 5 mg/L 16% of the time, the third lowest rate since monitoring began, and below 3.2 mg/L for 5% of all readings, the second lowest annual rate recorded. Both the 3.2 mg/L and 5 mg/L failure rates were much lower than the average failure rate over the prior 10-years of monitoring (11.2% for 3.2 mg/L; 24.4% for 5 mg/L). These improved oxygen conditions in Masonville Cove may be related to the lower algal concentrations recorded in 2019 (Table 2).

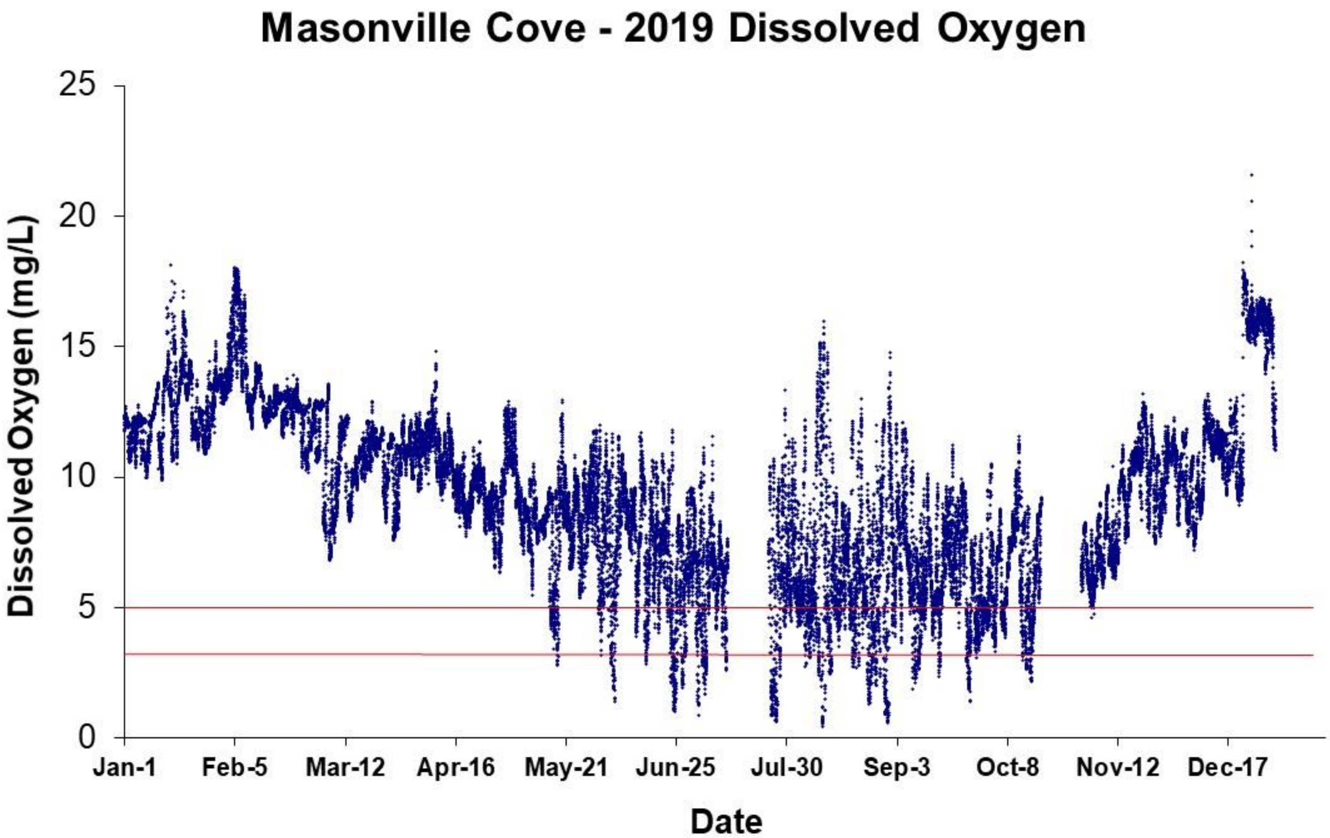

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2019. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove Continuous Monitor during June through November, 2009, March through October, 2010 and April through September, 2011 to 2019.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	**2019**
Dissolved Oxygen less than 5 mg/L	28.3%	20.0%	14.3%	30.6%	26.0%	24.9%	26.4%	33.0%	26.2%	14.7%	**16.0%**
Dissolved Oxygen less than 3.2 mg/L	9.9%	8.6%	8.2%	14.2%	11.7%	8.8%	13.5%	19.0%	13.4%	4.3%	**5.0%**

Chlorophyll

Chlorophyll concentrations tend to vary with and are an indicator of, algal (phytoplankton) levels. Readings above 15 micrograms per liter (µg/L) represent algal blooms that can negatively affect living resources. Chlorophyll concentrations greater than 50 µg/L represent significant algal blooms and concentrations above 100 µg/L represent severe blooms.

Chlorophyll data indicate significant bloom conditions within Masonville Cove starting late January into February (Figure 8). Concentrations dropped below 10 µg/L starting mid-February into March as numerous precipitation events impacted the region (Figure 3), flushing algae from Masonville Cove. Chlorophyll levels approached 50 µg/L again in early April, before dropping again in the middle of the month.

Chlorophyll sonde data were censored from the published dataset between April 20th and June 13th. DNR biologists were not able to access and service the continuous monitoring station during this period because of the presence of nesting eagles. After QA/QC protocols were applied to the data, all chlorophyll measurements collected during this time were considered suspect. When the dataset resumed in mid-June, chlorophyll readings indicate numerous significant or severe algal blooms occurred in Masonville Cove through the summer and remainder of the year (Figure 8). The highest chlorophyll readings occurred in late July (104.5 µg/L), early August (150.5 µg/L), late August (164 µg/L), early September (136.4 µg/L), early December (115.3 µg/L), and late December (231.1 µg/L). Also, samples collected by DNR biologists from Baltimore Harbor on December 9th and downstream of the Key Bridge on December 10th indicated a potentially harmful algal bloom (*Prorocentrum minimum*) within the Patapsco River. Chlorophyll concentrations at this time within Masonville Cove were over 100 µg/L.

As stated previously, chlorophyll readings greater than 15 µg/L and 50 µg/L indicate blooms with potential ecosystem effects and significant blooms, respectively. Table 2 lists the percentage of data readings that exceed these thresholds for Masonville Cove during the portion of the 2019 deployment that coincided with SAV growing season (March – October). Algal blooms during this period may impede the ability of SAV to grow and reproduce. In 2019, chlorophyll levels exceeded the 15 µg/L threshold during 27.6% of readings, the second lowest since monitoring began, and exceeded the 50 µg/L threshold during 1.0% of readings, also the second lowest annual rate (Table 2). This is the second consecutive year that both annual rates were much lower than the average rate over the prior years of monitoring (43.2% for 15 µg/L; 6.1% for 50 µg/L).

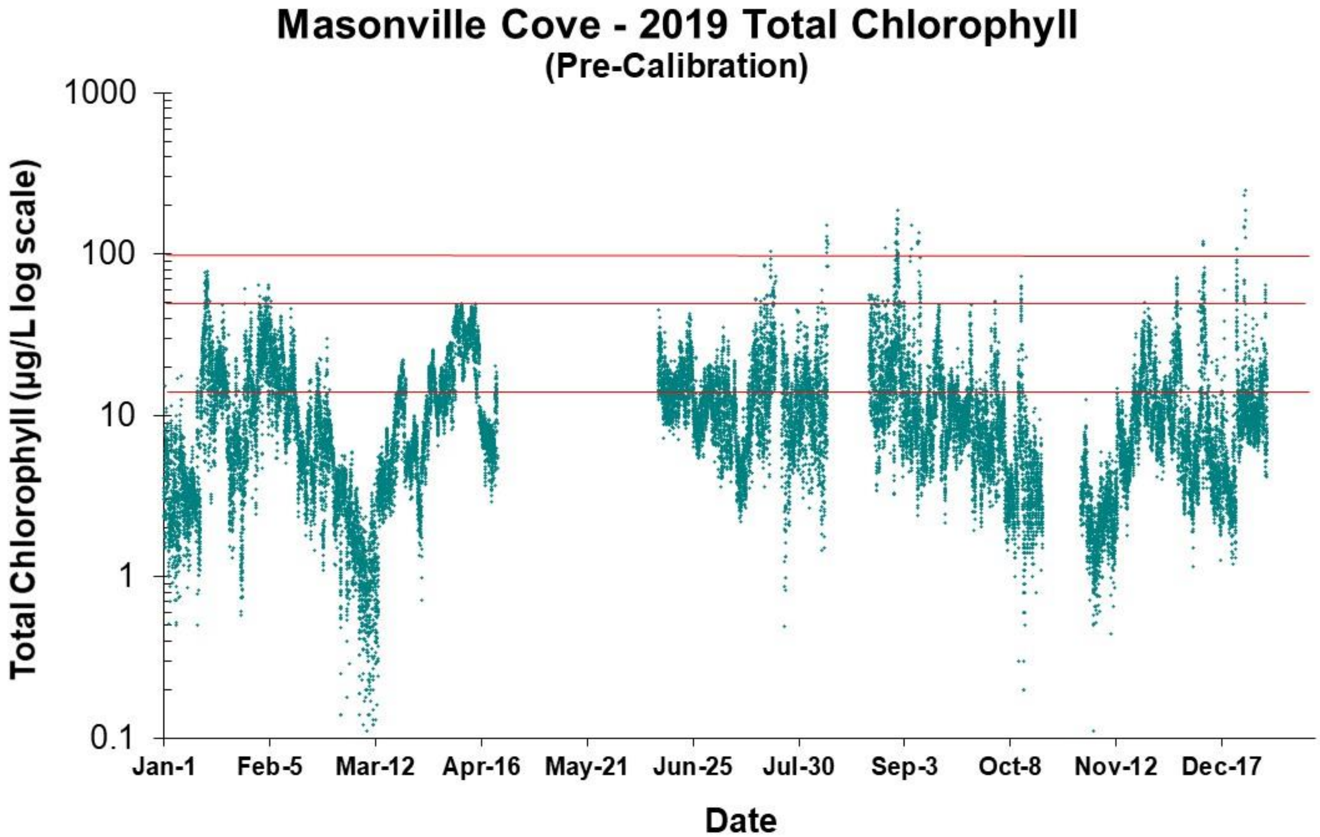

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2019. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 mg/L—are considered significant blooms—50 mg/L—or are considered severe blooms—100 mg/L.)*

Table 2. Chlorophyll threshold failure at Masonville Cove Continuous Monitor during June through November, 2009 and March through October, 2010 to 2019.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	**2019**
Readings greater than 15 µg/L	37.4%	59.0%	38.8%	55.6%	52.1%	36.2%	43.1%	40.1%	46.4%	23.3%	**27.6%**
Readings greater than 50 µg/L	3.3%	6.6%	0.9%	14.5%	10.5%	5.2%	8.9%	4.0%	5.5%	1.5%	**1.0%**

pH

pH readings tend to fluctuate between 7 and 9 in most Chesapeake Bay tidal waters, with spikes above 9 indicating potential algal blooms. High pH in the absence of high chlorophyll also can indicate that a blue-green algal bloom may have occurred (the chlorophyll sensors on the continuous monitors deployed at Masonville Cove are not designed to detect the wavelengths emitted by cyanobacteria). No pH values exceeded a value of 9 in 2019 at Masonville Cove (Figure 9). The highest pH values (8.9) occurred during severe algal blooms in early August and late December (Figure 8). In accordance with applied QA/QC protocols, much of the pH data in the second half of the year was found to be suspect and censored from the published dataset.

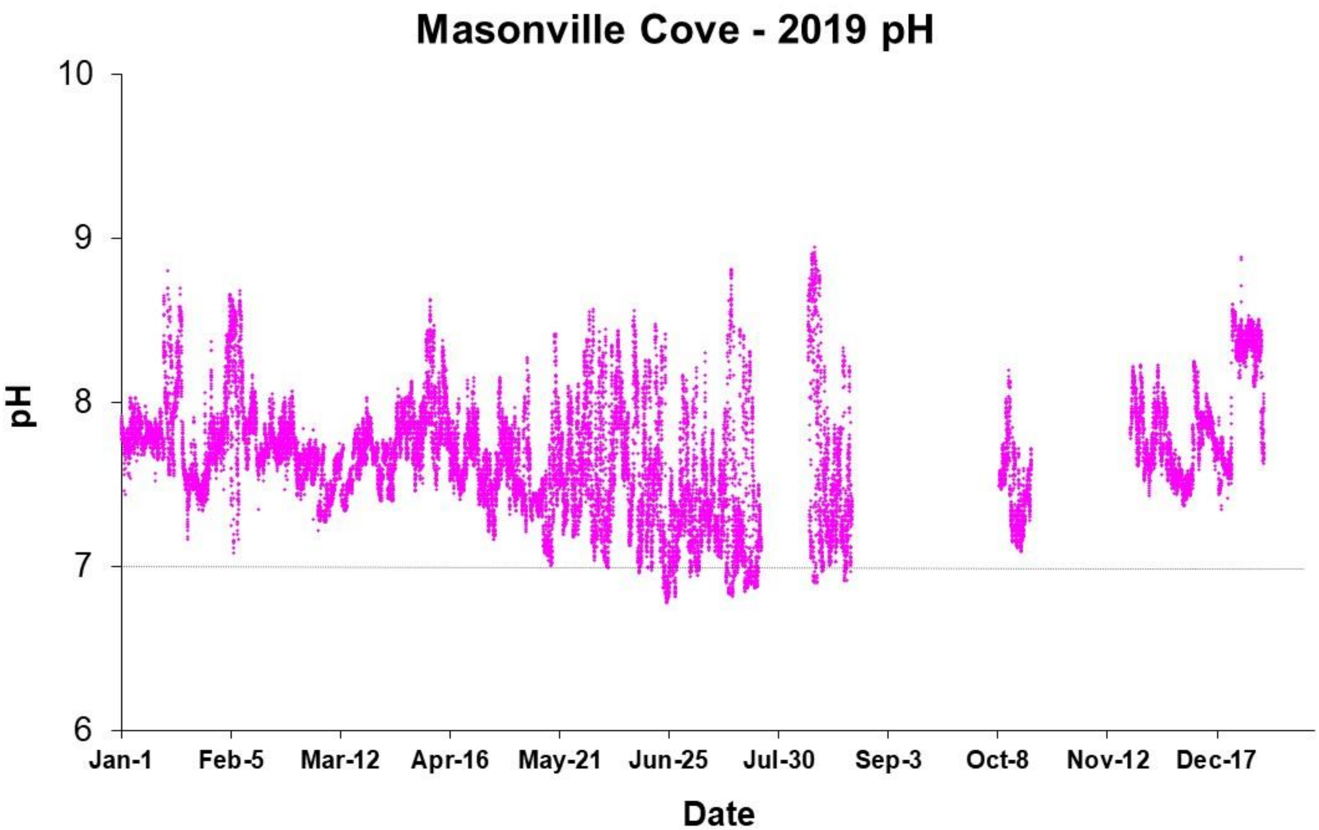

Figure 9. pH levels at Masonville Cove Continuous Monitor during 2019. *(Line indicates neutral pH.)*

Turbidity

Turbidity is quantified by measuring how much light is reflected from suspended particles in the water and is used to determine water clarity. Lower turbidity values indicate less reflection and, therefore, clearer water, while values above 7 Nephelometric Turbidity Units (NTU) are generally thought to be detrimental to SAV growth based on the effects of elevated turbidity in other systems (M. Trice, MD DNR, personal communication). During the year, there were two time periods when turbidity levels spiked extremely high to more than 100 NTU (Figure 10) and both of these occurred during and in the aftermath of heavy precipitation and discharge events. Readings also spiked other times during the year, generally following precipitation events, but the majority (53%) of turbidity values throughout the year were at or below 7 NTU (mean value: 8.9 NTU; median value: 6.7 NTU).

The first five months of 2019 were wetter than normal (Figure 3) and turbidity measurements during this time reflect this wet pattern and associated discharge events that brought high concentrations of particles and sediment into the Patapsco River. Through May, there were five turbidity spikes to at least 50 NTU, the mean turbidity value was 11.9 NTU, and the median value was 8.4 NTU. The highest turbidity value of the year (211 NTU) was recorded during this time period (January 21st) following over an inch of rain that fell on the region, which also washed existing snow cover into the waterways.

Turbidity data were censored from the published dataset between May 20th and June 13th. DNR biologists were not able to access and service the continuous monitoring station during this period because of the presence of nesting eagles. After QA/QC protocols were applied to the data, all turbidity measurements collected during this time were considered suspect. Following this data gap, the second half of 2019 was dryer than normal (Figure 3) and turbidity measurements reflect this pattern as there were only two turbidity spikes to at least 50 NTU during this time period The mean turbidity value between mid-June and the end of the year was 6.5 NTU and the median value 5.4 NTU.

Turbidity measurements above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. Although a slight majority (53%) of turbidity values in Masonville Cove were at or below 7 NTU in 2019, almost 57% of turbidity values during the SAV growing season (March through October) were above this threshold (Table 3). This rate was above the average of the prior ten years (51.2%). Thus, water clarity conditions in Masonville Cove in 2019, during the seasons most important to SAV growth, were considered poor.

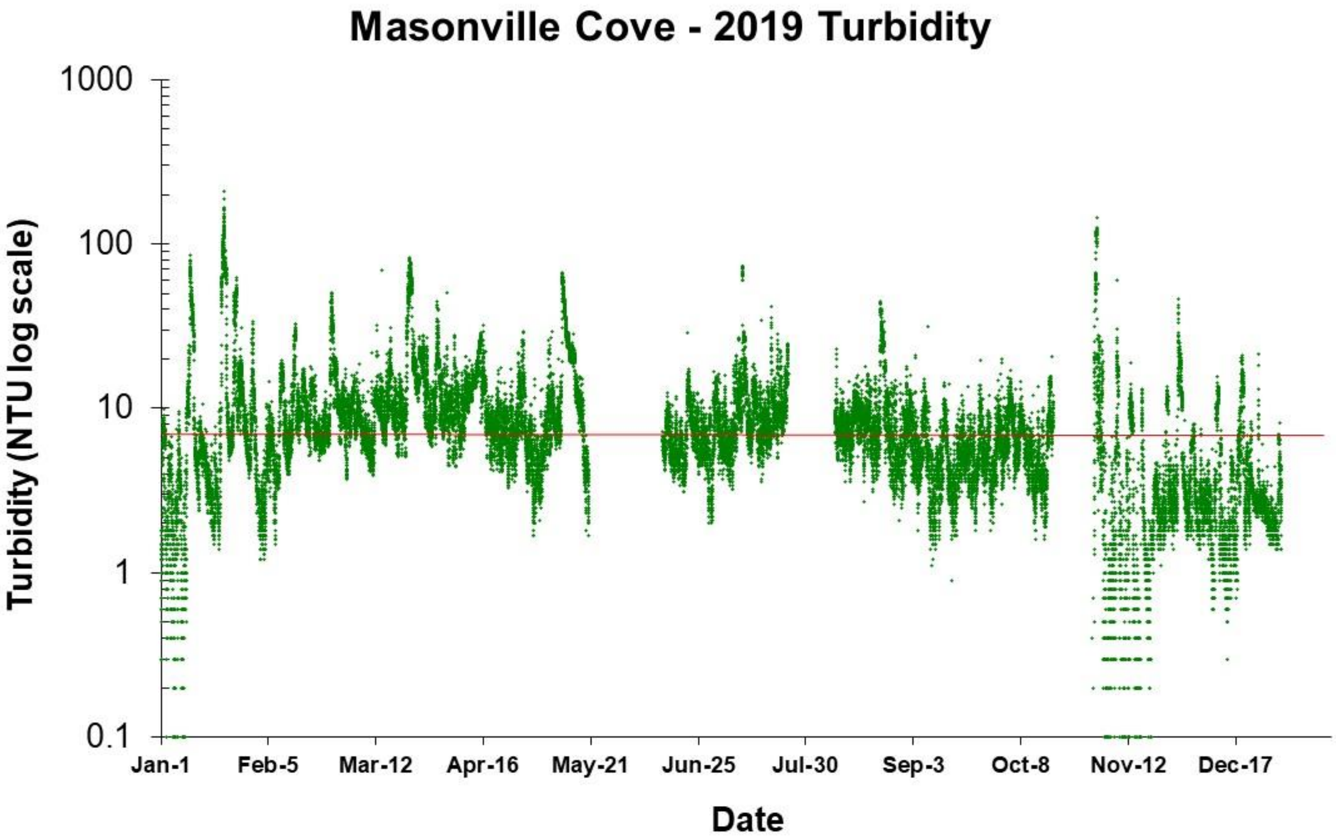

Figure 10. Turbidity levels at Masonville Cove Continuous Monitor during 2019. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failure at Masonville Cove Continuous Monitor during June through December, 2009 and March through October, 2010 to 2019.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	**2019**
Readings greater than 7 NTU	54.6%	60.1%	51.6%	35.0%	53.9%	52.9%	53.8%	34.9%	60.9%	53.8%	**56.9%**

Submerged Aquatic Vegetation (SAV) in the Patapsco River

SAV, or underwater grasses, are an important component of estuarine ecosystems. SAV provides habitat for juvenile fish and shellfish, supplies food for waterfowl, filters and oxygenates the water and helps stabilize bottom sediments. Since 1984, SAV within the Chesapeake Bay and associated tributaries has been assessed annually (with the exception of 1988) by the Virginia Institute of Marine Science (VIMS). Figure 11 shows total area and density of SAV within the Patapsco beginning in 1994 (the first year SAV was found in the river) through 2019.

Total area of SAV within the Patapsco River increased 350% between 2018 and 2019 and stands at 36% of the total restoration goal of 389 acres. All 140 acres of observed SAV was located in tributaries of the river and SAV was absent within Masonville Cove and the mainstem of the Patapsco. Poor water clarity and lack of viable seed banks may explain the lack of SAV coverage within Masonville Cove. However, 2019 was the best year for SAV in the Patapsco River since 2005 when 72% of the restoration goal was achieved, including SAV beds within Masonville Cove. Both 2004 and 2005 were generally very good years for SAV throughout the Chesapeake Bay region and the increases in coverage have been attributed to an accompanying population explosion and range expansion of dark false mussels (*Mytilopsis leucophaeata*). These filter feeders may have increased water clarity and allowed SAV coverage to significantly expand (L. Karrh, MD DNR, personal communication). In 2006, mussel populations declined, SAV beds disappeared in Masonville Cove and total area of SAV within the Patapsco decreased 83%. In 2010, there was no SAV in the entire Patapsco River.

The increase in SAV coverage seen in the Patapsco River in 2019 follows the recent trends found throughout the Chesapeake Bay watershed. Expansions of SAV beds have been recorded in many tributaries over the past few years. Bay-wide, however, SAV coverage declined 38% in 2019 to just over 66,000 acres.

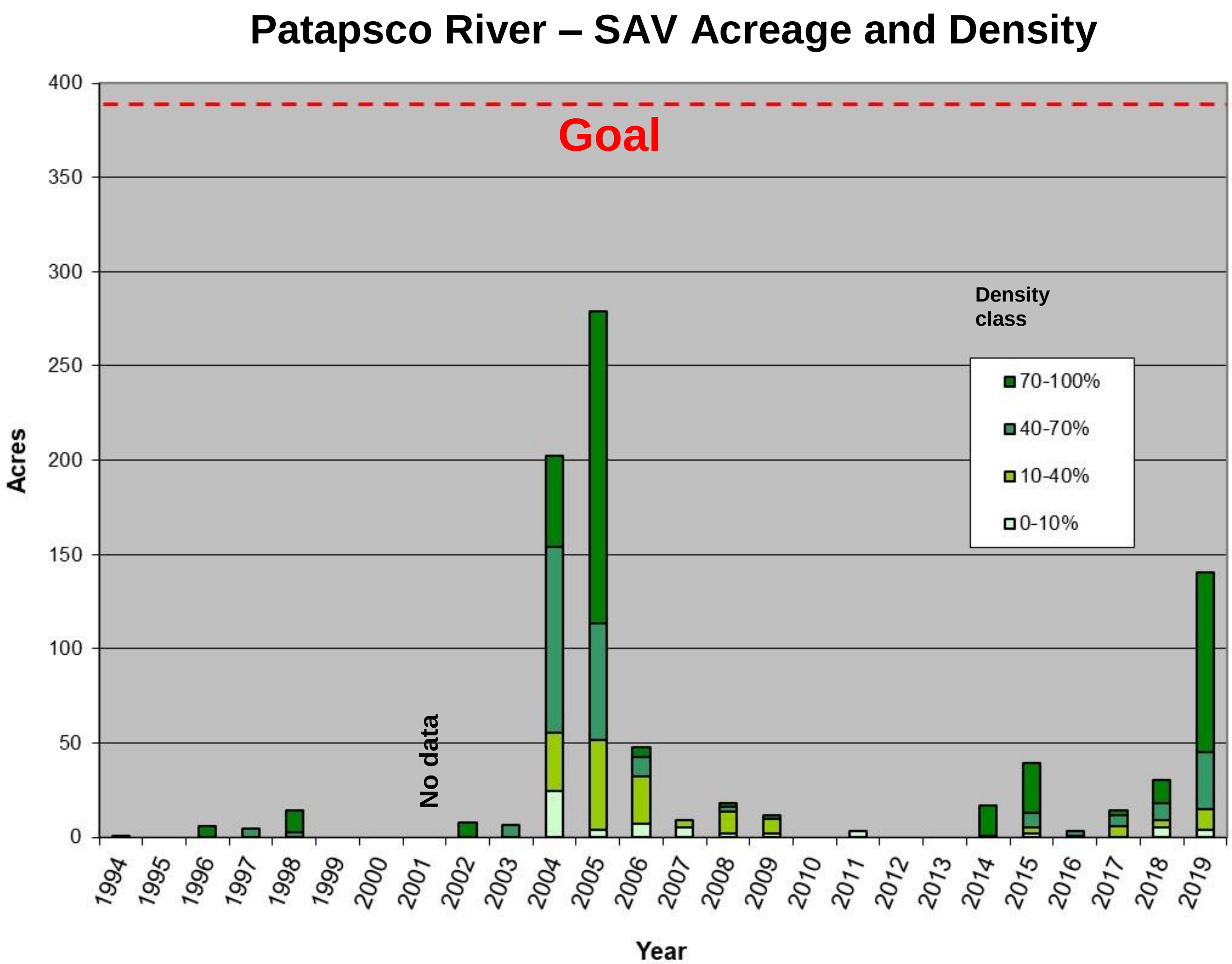

Figure 11. Total area and density of SAV in the Patapsco River between 1994 and 2019. (*Restoration goal is 389 acres)*

Pigments, Suspended Solids and Secchi Depths

Bi-weekly grab samples of water were taken at the Masonville Cove station when the YSI meters were exchanged during continuous monitoring service visits. Samples collected during November through March were collected monthly instead of bi-weekly (Table 4). Secchi depth, a measure of water clarity, was also recorded at the Masonville Cove station each time a grab sample was collected.

For the grab samples, the water was processed in the field using vacuum filtration and the resulting particulate samples were delivered to the laboratory for analysis. Samples collected during continuous monitoring service visits were analyzed for pigments and suspended solids. All analyses were performed by the University of Maryland's Chesapeake Biological Laboratory (CBL) Nutrient Analytical Services Laboratory (NASL). For details on methods, procedures, analysis and detection limits, refer to the Quality Assurance Project Plan (QAPP) for the Shallow Water Monitoring Program. This document can be found at: http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/SWM_QAPP_2019_2020_Draft_v3.pdf. Results of the laboratory analyses are presented graphically in Appendix A (Figures A-1 through A-3). Secchi depth measurements are presented in Figure A-4. The suspended sediments, pigments and Secchi depth data are also presented in Table A-1 of Appendix A.

Table 4. Deployment and calibration record for Masonville Cove continuous monitor in 2019.

Scheduled calibration date	Samples collected	Comment
January 10th, 2019	Yes	Telemetry malfunctioned
February 7th, 2019	Yes	Telemetry data reestablished
March 7th, 2019	Yes	
April 4th, 2019	Yes	
April 15th, 2019	Yes	
June 13th, 2019	Yes	Regular service visits resumed following enforced not entry policy in May due to eagle nesting site
June 27th, 2019	Yes	
July 11th, 2019	Yes	
July 24th, 2019	Yes	
August 8th, 2019	Yes	
August 22nd, 2019	Yes	
September 4th, 2019	Yes	Telemetry data reestablished following malfunction on August 22nd
September 19th, 2019	Yes	
October 8th, 2019	Yes	
October 31st, 2019	Yes	
November 19th, 2019	Yes	
December 9th, 2019	Yes	
December 10th, 2019	No	New telemetry equipment installed

Pigments

Chlorophyll values at Masonville Cove were consistently below 20 µg /L for the first half of 2019. On July 24th, a slightly elevated chlorophyll value of 27 µg /L was measured, followed by a peak value of 176.55 µg /L on August 8th. As previously noted, chlorophyll concentrations in excess of 50 µg/L may be indicative of a significant algal bloom, and concentrations above 100 µg /L may signal a severe algal bloom. The August 8th peak value was well above the 100 µg /L threshold for a severe algal bloom. Following the peak on August 8th, sampling dates on August 22nd and September 4th showed reduced, but still elevated, concentrations of 32 µg /L and 46 µg /L chlorophyll, respectively. Chlorophyll levels dropped below 10 µg /L through October and November, before rising slightly to 26 µg /L in December.

The greatest pheophytin values (11 µg /L – 17 µg /L) were measured in August and September in the weeks following the August 8th peak chlorophyll value. During all other months in 2019, pheophytin values remained below 10 µg /L.

Suspended solids

An unusually high suspended solids concentration of 100 mg/L was measured on January 10th at Masonville Cove. Values around 20 mg/L occurred on August 8th (coincident with an algal bloom), in late September, in early October, and again in December. For all other samples in 2019, total suspended solids concentrations were generally below 10 mg/L.

Secchi depths

Secchi depth is a measurement of water clarity and shows an inverse relationship to suspended solids concentration. As suspended solids in the water increase, water clarity decreases, and Secchi depth measurements decline. This relationship was observed in the Secchi depth measurements at Masonville Cove, with the lowest values (0.2m) being recorded in January when suspended sediments peaked at 100 mg/L, and in August during an algal bloom. The highest Secchi depth values (>1.0m), were observed in February, late October, and November, and represent periods of greater water clarity.

<u>Ambient Water Quality</u>

Ambient water quality data (salinity, dissolved oxygen, water temperature, and pH) were collected concurrently with the grab samples. The data values are presented graphically in Figures A-5 to A-8 in Appendix A. These water quality parameters are measured as a profile, with readings recorded at 0.5m depth intervals at the station. In the graphs, the individual readings within a profile are represented by separate data points. The solid line on each graph intersects the mean value for the parameter on each sampling date. All data values for dissolved oxygen, pH, salinity and water temperature are provided in Table A-2 of Appendix A.

Salinity

In 2019, salinity values in Masonville Cove began with a low value around 1 ppt in January and followed a generally increasing trend through the year, ending with a high value of 12.7 ppt in December. This general pattern was interrupted by a peak in salinity in March, and slight dips in salinity during July and November. The March peak in values may have been the result of salt from winter roadway treatment entering the waterway during spring rains. The lower salinity values in July and November could indicate an increase in freshwater input to the system from either rainfall or runoff.

Dissolved oxygen

Dissolved oxygen concentrations in Masonville Cove follow a seasonal trend of higher values

(>10 mg/L) in the cooler months (January-February and November-December) and lower values (<8 mg/L) in the warmer months (June-September). Dissolved oxygen measurements in the summer months also reveal marked differences between oxygen levels in the shallow surface waters and in the deeper bottom waters. In the summer months, surface measurements of dissolved oxygen were always greater than 6 mg/L, however bottom water dissolved oxygen values frequently dropped below the 5 mg/L threshold that is considered necessary to support marine life. On August 8th, during an algal bloom event, dissolved oxygen values at Masonville Cove rose in response to greater photosynthetic activity during the bloom, resulting a mean value of 10.4 mg/L.

Water temperature and pH

Water temperatures also varied seasonally at Masonville Cove. Water temperatures around 4°C were measured from January through March 2019. As the weather warmed, water temperatures gradually rose to a peak value of 27.9°C on August 22nd, and then declined steadily to around 7°C on December 9th.

Measured pH values at Masonville Cove generally fluctuated between 7 and 8.5 in 2019. An increase in pH values is often observed with algal blooms, and this was evident during the algal bloom event on August 8th when a peak in pH values (range: 8.3 - 8.6) was measured at the monitoring site.

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2019. Continuous monitoring data provide a critical function for assessing the health of Maryland's tidal waters in areas historically lacking water quality information. Shallow water data provide information about the effects of nutrient pollution and weather events on Masonville Cove and the Patapsco River as a whole. In 2019, algal and dissolved oxygen conditions were improved as compared to prior years. Samples collected in the Patapsco River during a severe algal bloom in December did indicate the presence of a potentially harmful algal species, *Prorocentrum minimum*. Finally, the numerous precipitation and discharge events in 2019 led to water clarity conditions that were below average and no submerged aquatic vegetation was found in Masonville Cove. Thus, although conditions in Masonville Cove appear to have improved in terms of algal and dissolved oxygen concentrations, conditions remain poor for living resources in the upper Patapsco River.

Shallow water monitoring information is not only used for characterizing the health of shallow water habitats, but it is also useful for: 1) assessing Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll in shallow water habitats; 2) determining attainment or nonattainment of shallow water habitats for their designated uses; 3) assessing SAV habitats and identifying potential SAV restoration sites; 4) providing information to better understand ecosystem processes and the impact of extreme events (e.g. hurricanes, high flows, sanitary sewer overflows) in shallow water and open water environments; 5) providing data for calibrating the Bay Eutrophication and Watershed Model; and 6) assessing mitigation efforts in relation to the dredged material containment facility at the Masonville Marine Terminal.

References

COMAR (Code of Maryland Regulations). 1995. Code of Maryland Regulations: 26.08.02.03 – Water Quality Criteria Specific to Designated Uses. Maryland Department of the Environment. Baltimore, Maryland.

Jordan, S., C. Stegner, M. Olson, R. Batiuk and K. Mountford. 1992. Chesapeake Bay dissolved oxygen goal for restoration of living resources habitats. Chesapeake Bay Program, Reevaluation Report #7c. CBP/TRS88/93. Annapolis, Maryland.

Leffler, M. and J. Greer. 2001. Taking on toxics in Baltimore Harbor. Maryland Marine Notes 19(2). https://www.mdsg.umd.edu/sites/default/files/files/MN19_2.PDF

Appendix A

Results of laboratory and ambient water quality analyses for:
Masonville Cove Pier (Station XIE4742)

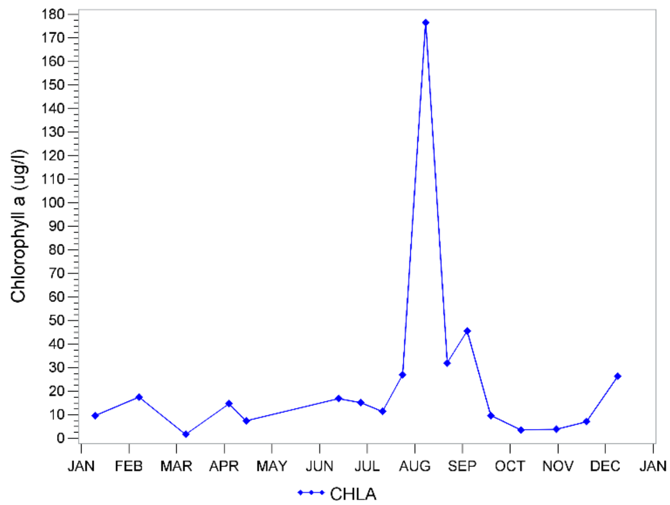

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2019.

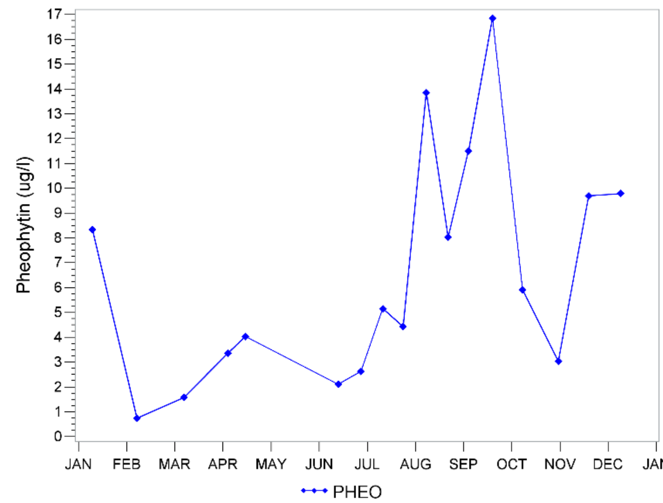

Figure A-2. Pheophytin concentrations at Masonville Cove in 2019.

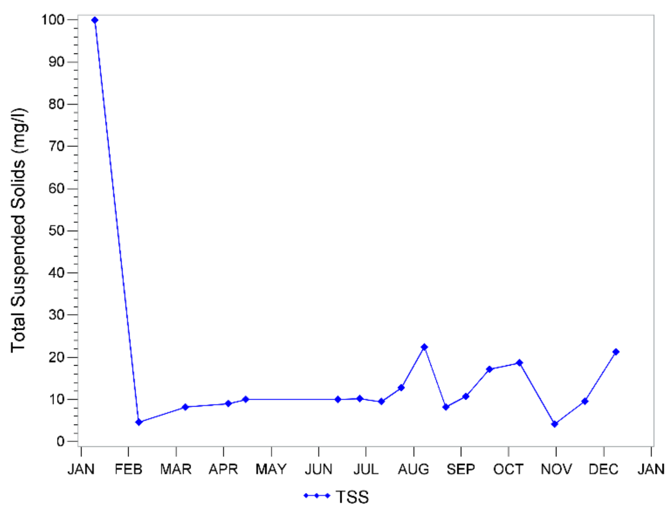

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2019.

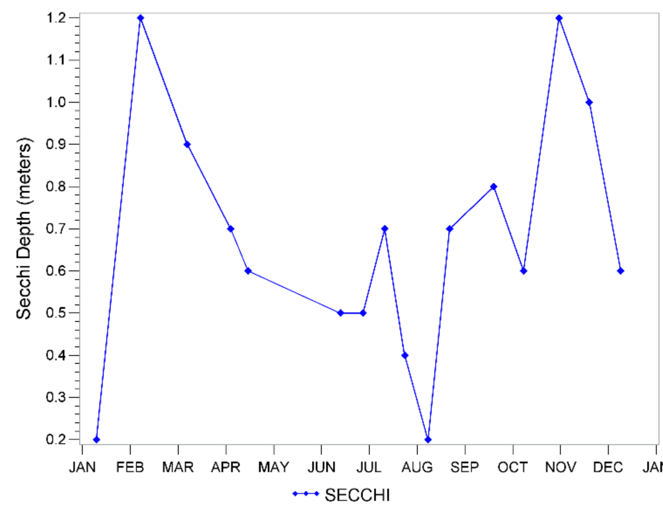

Figure A-4. Secchi depth at Masonville Cove in 2019.

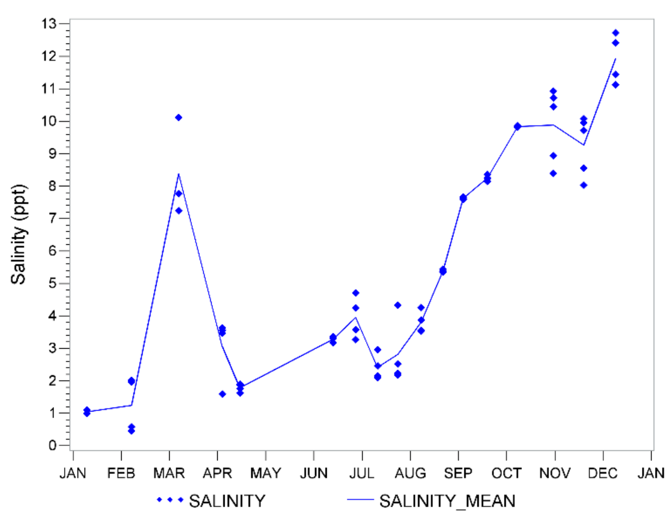

Figure A-5. Salinity concentrations at Masonville Cove in 2019.

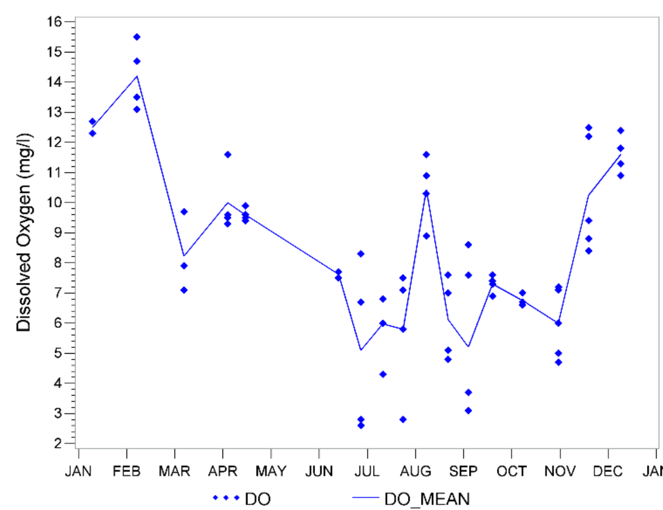

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2019.

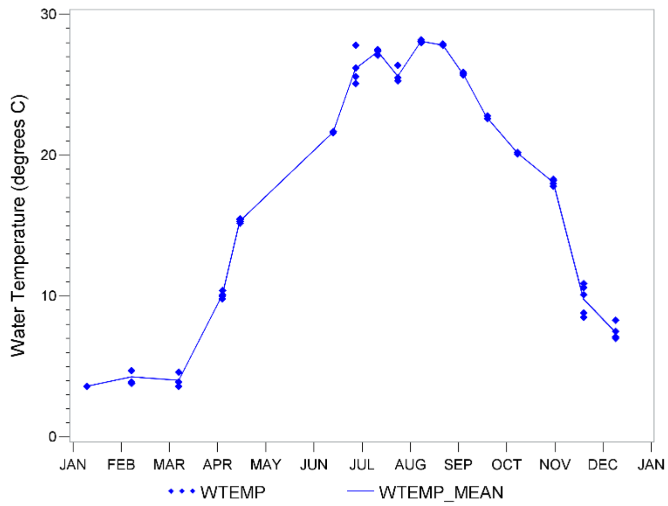

Figure A-7. Water temperature at Masonville Cove in 2019.

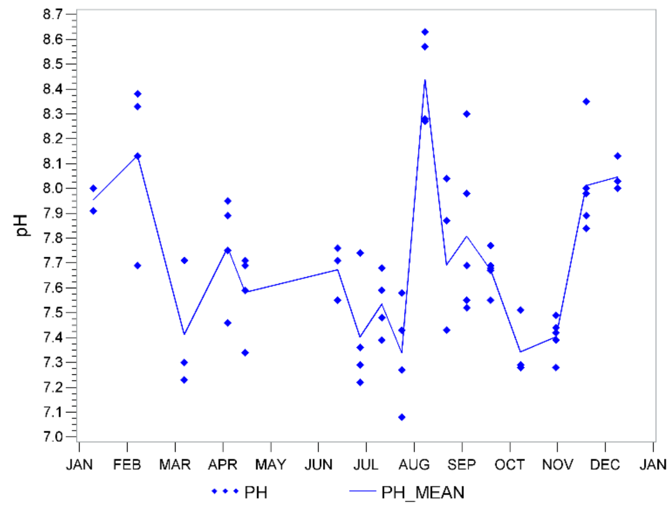

Figure A-8. Values of pH at Masonville Cove in 2019.

Graphs with multiple y-values on a single point on the x-axis represent values measured at different depths in the water column. In such cases, lines intersect the mean value.

Table A-1. Discrete Continuous Monitoring Data for Chlorophyll-a, Pheophytin, Total Suspended Solids, and Secchi Disk Depth for Masonville Cove (XIE4742) in 2019.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Pheophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
01/10/19	1	9.612	8.330	100.0	0.2
02/07/19	1	17.515	<0.740	4.6	1.2
03/07/19	1	1.709	1.581	8.2	0.9
04/04/19	1	14.685	3.351	9.0	0.7
04/15/19	1	7.476	4.037	10.0	0.6
06/13/19	1	16.874	2.115	10.0	0.5
06/27/19	1	15.166	2.627	10.2	0.5
07/11/19	1	11.481	5.153	9.5	0.7
07/24/19	1	26.967	4.432	12.8	0.4
08/08/19	1	176.55[1]	13.85[1]	22.5	0.2
08/22/19	1	32.040	8.031	8.2	0.7
09/04/19	1	45.568	11.499	10.7	No data
09/19/19	1	9.612	16.853	17.2	0.8
10/08/19	1	3.560	5.910	18.7	0.6
10/31/19	1	3.845	3.033	4.2	1.2
11/19/19	1	7.049	9.697	9.6	1.0
12/09/19	1	26.344	9.790	21.3	0.6

1) Poor replication between pads, mean reported

Table A-2. Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2019 (continued on next page).

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
01/10/19	0.5	12.3	8.00	0.99	3.6
01/10/19	1.0	12.7	7.91	1.10	3.6
02/07/19	0.5	13.1	8.13	0.45	4.7
02/07/19	1.0	13.5	7.69	0.58	4.7
02/07/19	1.5	15.5	8.38	1.96	3.9
02/07/19	2.0	14.7	8.33	2.01	3.8
03/07/19	0.5	7.9	7.30	7.25	3.9
03/07/19	1.0	9.7	7.71	7.77	3.6
03/07/19	1.7	7.1	7.23	10.12	4.6
04/04/19	0.5	11.6	7.95	1.59	10.1
04/04/19	1.0	9.5	7.46	3.63	9.8
04/04/19	1.5	9.6	7.75	3.47	10.4
04/04/19	1.9	9.3	7.89	3.56	10.0
04/15/19	0.5	9.6	7.69	1.62	15.5
04/15/19	1.0	9.9	7.71	1.76	15.4
04/15/19	1.5	9.4	7.59	1.89	15.2
04/15/19	1.8	9.5	7.34	1.87	15.3
06/13/19	0.5	7.7	7.76	3.18	21.7
06/13/19	1.0	7.7	7.55	3.31	21.6
06/13/19	1.9	7.5	7.71	3.36	21.7
06/27/19	0.5	8.3	7.74	3.27	27.8
06/27/19	1.0	6.7	7.36	3.57	26.2
06/27/19	1.5	2.8	7.22	4.24	25.6
06/27/19	2.1	2.6	7.29	4.71	25.1
07/11/19	0.5	6.8	7.68	2.10	27.5
07/11/19	1.0	6.8	7.48	2.15	27.4
07/11/19	1.5	6.0	7.59	2.46	27.5
07/11/19	2.0	4.3	7.39	2.96	27.1
07/24/19	0.5	7.5	7.43	2.18	25.3
07/24/19	1.0	7.1	7.58	2.23	25.3
07/24/19	1.5	5.8	7.27	2.52	25.5
07/24/19	1.9	2.8	7.08	4.33	26.4

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2019.

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
08/08/19	0.5	11.6	8.63	3.56	28.2
08/08/19	1.0	10.3	8.28	3.53	28.0
08/08/19	1.5	10.9	8.57	3.87	28.1
08/08/19	2.1	8.9	8.27	4.26	28.1
08/22/19	0.5	7.6	7.87	5.37	27.9
08/22/19	1.0	7.0	8.04	5.35	27.8
08/22/19	1.5	5.1	7.43	5.38	27.8
08/22/19	1.8	4.8	7.43	5.44	27.8
09/04/19	0.5	8.6	8.30	7.60	25.9
09/04/19	1.0	7.6	7.98	7.62	25.7
09/04/19	1.5	3.7	7.52	7.59	25.7
09/04/19	2.0	3.1	7.55	7.65	25.8
09/04/19	2.4	3.1	7.69	7.67	25.8
09/19/19	0.5	6.9	7.55	8.15	22.8
09/19/19	1.0	7.6	7.77	8.36	22.6
09/19/19	1.5	7.4	7.69	8.24	22.6
09/19/19	2.0	7.3	7.68	8.25	22.6
09/19/19	2.4	7.3	7.67	8.24	22.6
10/08/19	0.5	6.7	7.28	9.82	20.2
10/08/19	1.0	7.0	7.51	9.81	20.1
10/08/19	1.5	6.7	7.29	9.86	20.2
10/08/19	1.9	6.6	7.29	9.84	20.2
10/31/19	0.5	7.1	7.49	8.39	18.0
10/31/19	1.0	7.2	7.28	8.94	17.8
10/31/19	1.5	6.0	7.44	10.45	18.2
10/31/19	2.0	5.0	7.39	10.72	18.2
10/31/19	2.3	4.7	7.42	10.93	18.3
11/19/19	0.5	12.5	8.35	8.03	8.5
11/19/19	1.0	12.2	8.00	8.56	8.8
11/19/19	1.5	9.4	7.98	9.72	10.1
11/19/19	2.0	8.8	7.89	9.95	10.6
11/19/19	2.6	8.4	7.84	10.08	10.9
12/09/19	0.5	11.8	8.13	11.13	7.1
12/09/19	1.0	12.4	8.00	11.44	7.0
12/09/19	1.5	11.3	8.03	12.42	7.5
12/09/19	1.9	10.9	8.03	12.73	8.3