MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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2017 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

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2017 Masonville Cove – Patapsco River
Shallow Water Monitoring Data Report

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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 prior years due to icing conditions. In continuation of this project, a water quality monitor was deployed off the Masonville Cove pier during the entirety of 2017.

Water quality conditions in Masonville Cove during 2017, as in the rest of the Chesapeake Bay watershed, were influenced by meteorological events. Heavy rains and several associated sanitary sewer overflows in early April and late July led to massive discharge events that affected salinity and turbidity. After three years of degrading conditions, dissolved oxygen concentrations improved in 2017, but chlorophyll concentrations degraded from the prior year and algal blooms were frequent in Masonville Cove. Also the potentially harmful algal species *Heterocapsa rotundata* and *Prorocentrum minimum* were observed in the Patapsco River in February and in November/December. Lastly, turbidity measurements indicated the worst water clarity, in terms of increased threshold failure rates, since monitoring began in Masonville Cove in 2009. All 2017 continuous monitoring data, as well as data from previous years, are available on the DNR "Eyes on the Bay" website (eyesonthebay.dnr.maryland.gov/contmon/ContMon.cfm). Data from grab samples are available through the Chesapeake Bay Program's Data Hub (chesapeakebay.net/data). The most recent seven days of water quality data can also be viewed on the "Eyes on the Bay" Masonville Cove webpage (eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm). Data collected in 2017 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: eyesonthebay.dnr.maryland.gov/contmon/GetConMonDataHub_StationTable.cfm?station=XIE4742&DataHubID=1930&startdate=1-1-2017&enddate=12-31-2017.

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 2017, 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 2017. The other two sites were deployed adjacent to the National Aquarium in the Baltimore Harbor.

Description of continuous monitoring

For the entirety of 2017, 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. In 2017, DNR also developed an "Eyes on the Bay" webpage specific to Masonville Cove that displays charts and data from the most recent seven days. This page can be found at: eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm.

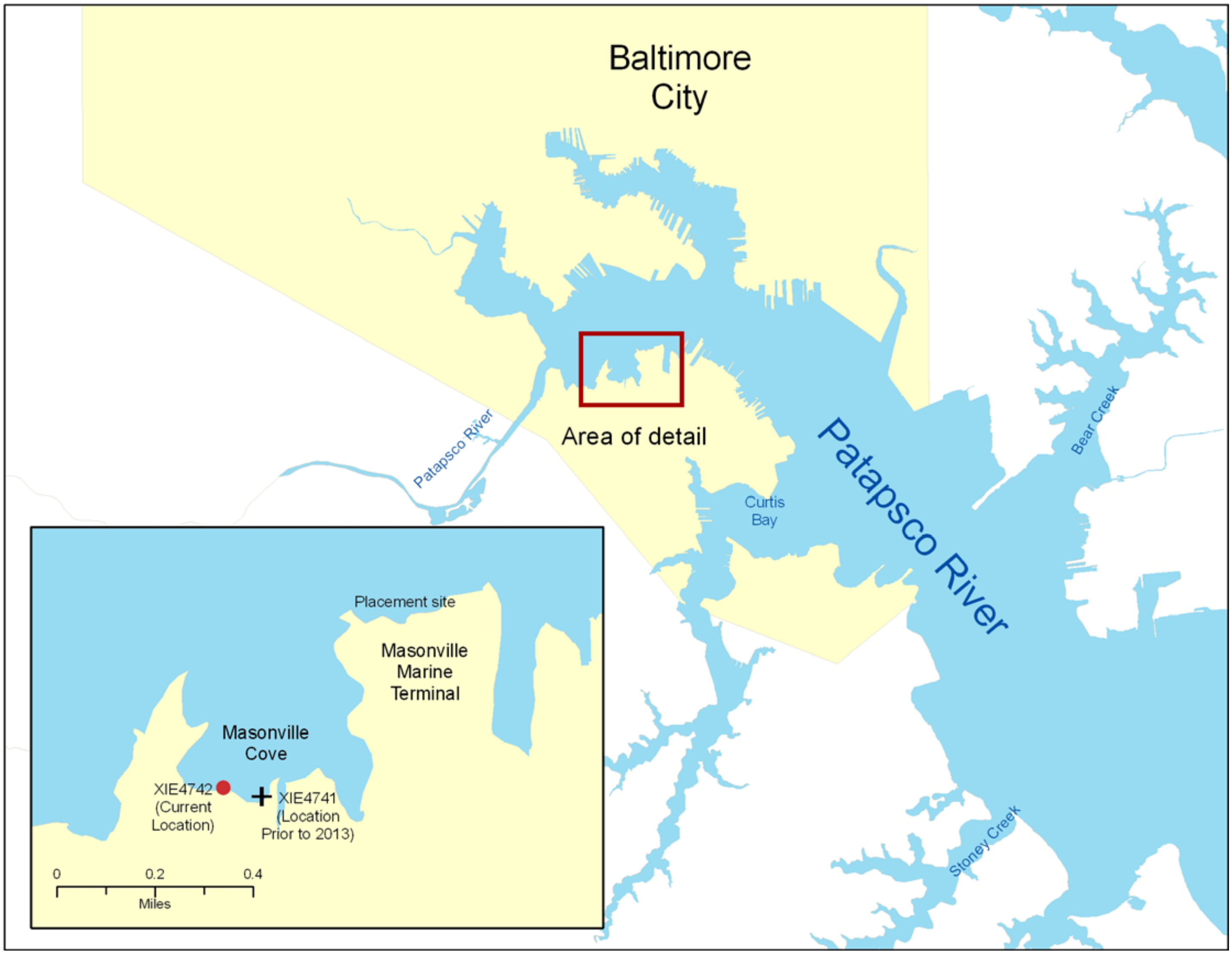

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2017 continuous monitor location within the cove, the location of the monitor prior to 2013 and the approximate site for dredged material placement.

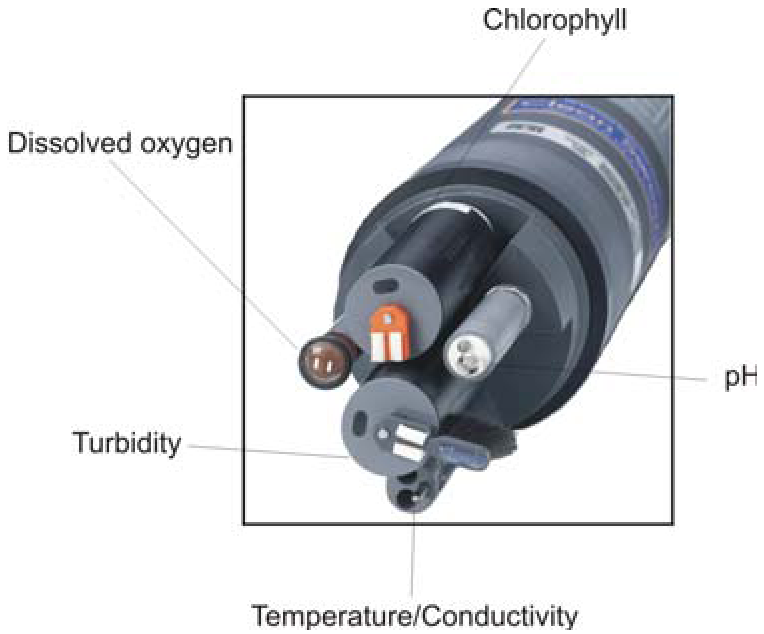

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

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 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 2017, the continuous monitor at Masonville Cove was deployed the entire year. Data sondes collected 30,481 data records and 20 calibration samples were collected and analyzed in 2017. Automated telemetry generally operated throughout the deployment of the sonde, 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. Malfunctions to water quality monitoring sondes did preclude data collection between March 12th and April 4th, October 5th and October 19th and December 21st and December 31st. Additional gaps seen in the data are where questionable data were removed for quality assurance purposes.

2017 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).

Annual precipitation for 2017 at Baltimore Washington International (BWI) Thurgood Marshall Airport was below the 30-year average (Figure 3) for the second consecutive year. Total precipitation was below monthly averages in 8 of the 12 months and 45% of the total annual precipitation fell in the three wettest months (Figure 3). July was the wettest month in 2017, as total monthly rainfall was 74% above the long-term average. Two events on July 6th (~1.5 inches) and the largest single precipitation event of 2017 on July 28th-29th (~4 inches) accounted for most of the July rainfall. Precipitation at the end of July also was associated with multiple reported sanitary sewer overflows in Baltimore City and County that spilled over 8 million gallons of untreated, diluted wastewater into the watershed.

Daily mean discharge at the USGS gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2017 (Figure 4). Gage data show numerous spikes throughout 2017, which are indicative of the precipitation events that affected the region during the year. Flows during the beginning and end of 2017 were below the daily median much of the time, reflecting the rainfall deficit during those months (Figure 3). The largest spikes occurred during heavy rains in April and May and again in July and August. The largest flow of the year, which was over 15-times greater than the daily median, occurred on April 6th and was correlated with a storm that dropped approximately 1.5 inches of rain on Central Maryland.

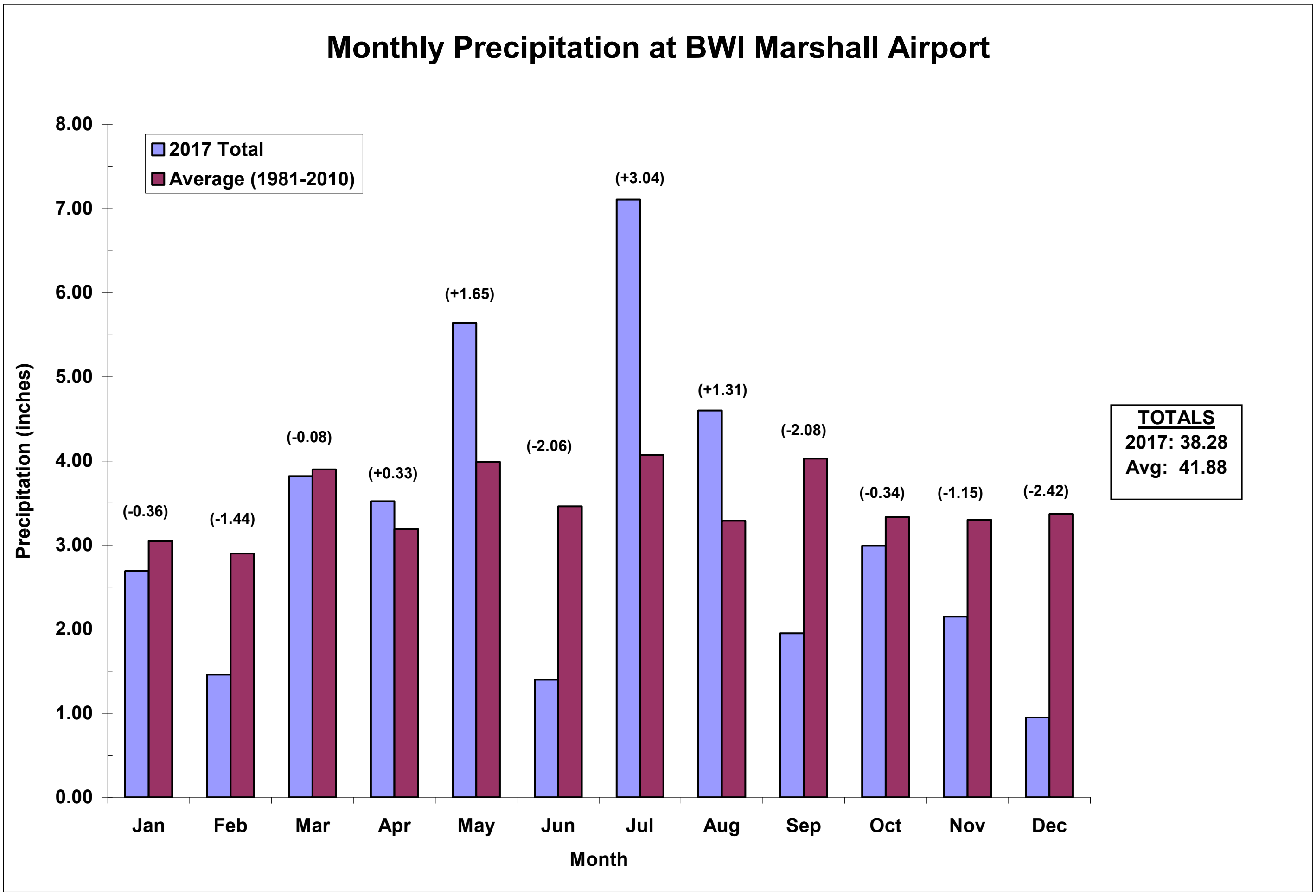

Figure 3. Total 2017 monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages. Data source: National Weather Service (weather.gov/media/lwx/climate/bwiprecip.pdf).

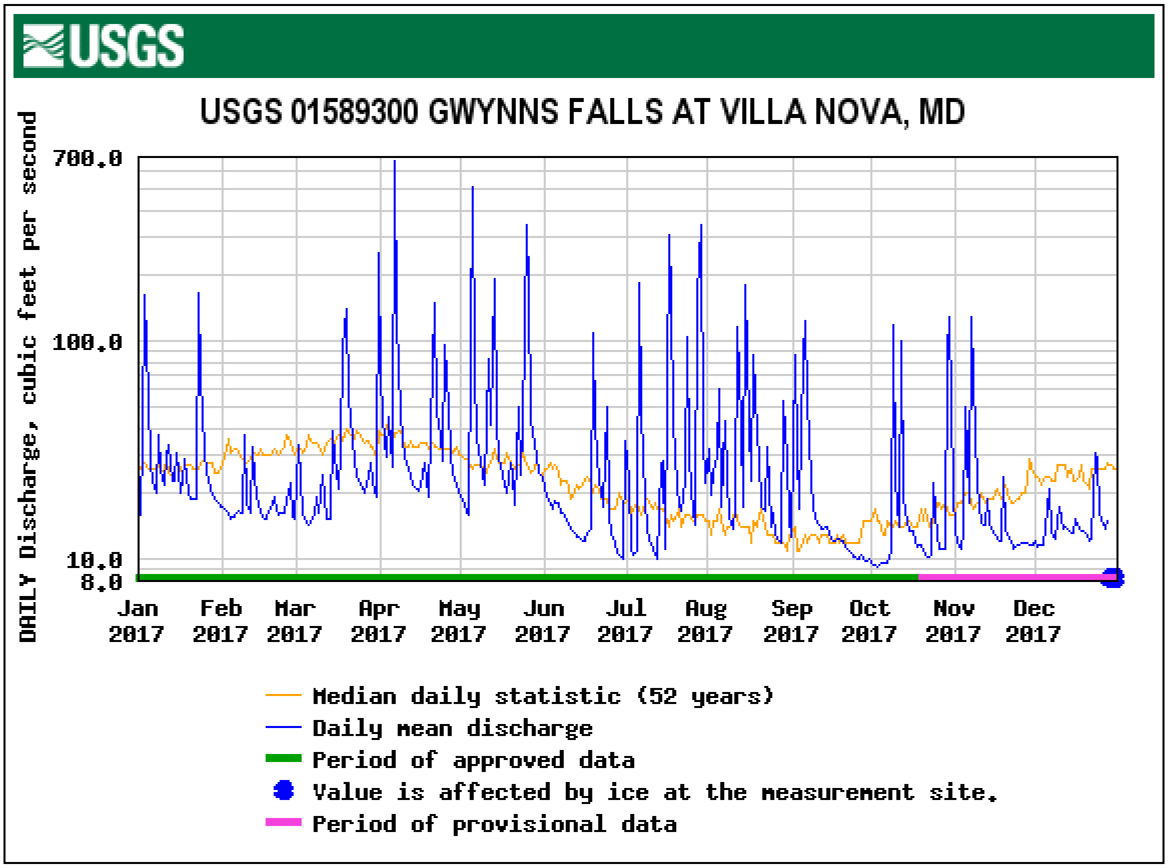

Figure 4. 2017 daily discharge in cubic feet per second measured at a USGS gaging station west of Masonville Cove. Graph courtesy of the United States Geological Survey (waterdata.usgs.gov/nwis/dv/?site_no=01589300).

<u>2017 Continuous Monitoring Data</u>

Water Temperature

Water temperature at Masonville Cove rose predictably as air temperatures increased during the summer months (Figure 5). Water temperature peaked at approximately 32°C (89° F) on July 22nd, remained generally above 25-26°C (77-79° F) through late September, although temperatures dropped temporarily in early and mid-September. Water temperature then gradually declined with air temperatures 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).

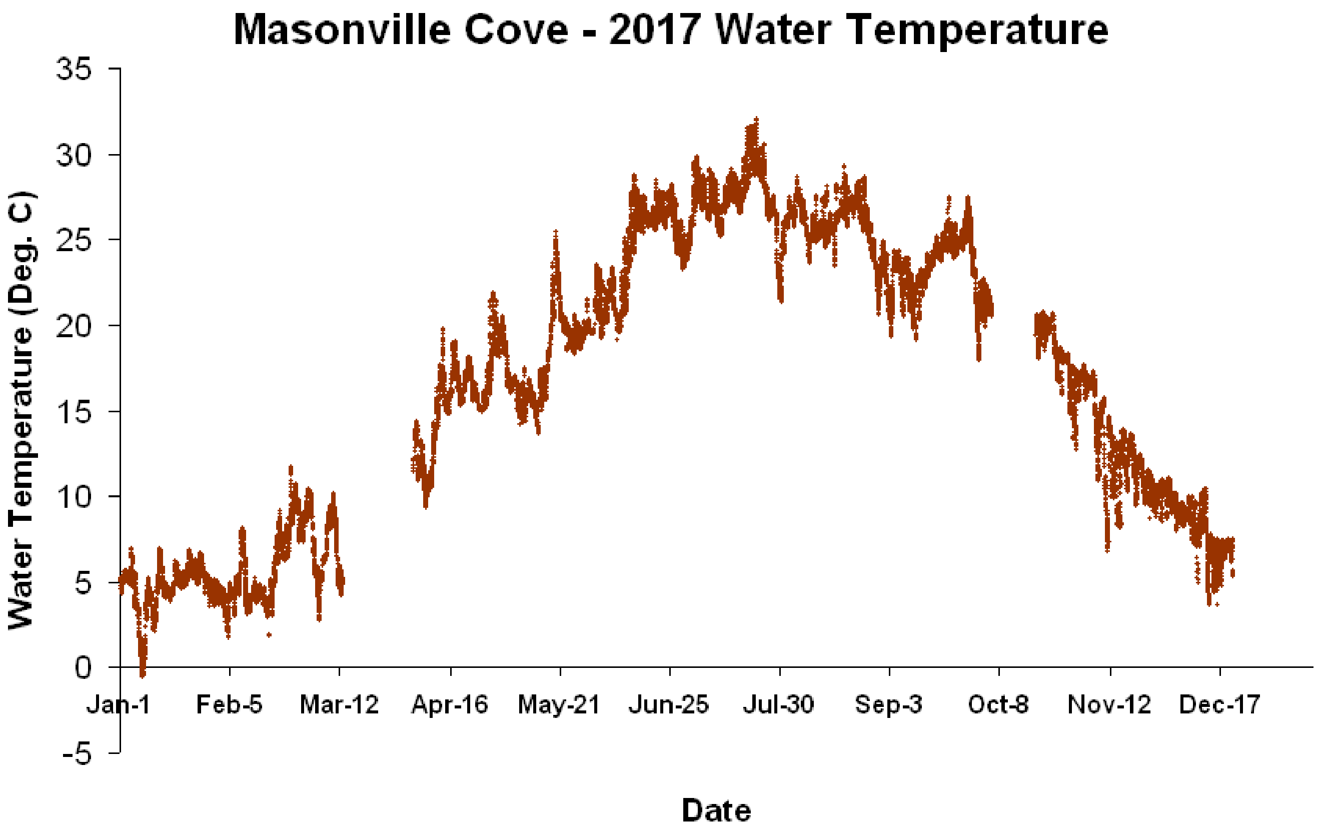

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2017.

Salinity

Salinity tends to vary with precipitation and streamflow. The overall salinity trend in 2017 (Figure 6) began with generally higher salinities in late winter and early spring, including the highest measured value (17 parts per thousand – ppt) on January 9th. Wet months in April and May (Figure 3) coincided with a drop in salinity values that remained suppressed through much of the summer. Heavy rains on July 28th-29th led to an eightfold drop in salinity and the lowest value of the year (0.52 ppt) on July 29th. The region experienced a rainfall deficit of 6 inches over the last 4 months of the year (Figure 3), which was associated with a general rise in salinity to approximately 14 ppt.

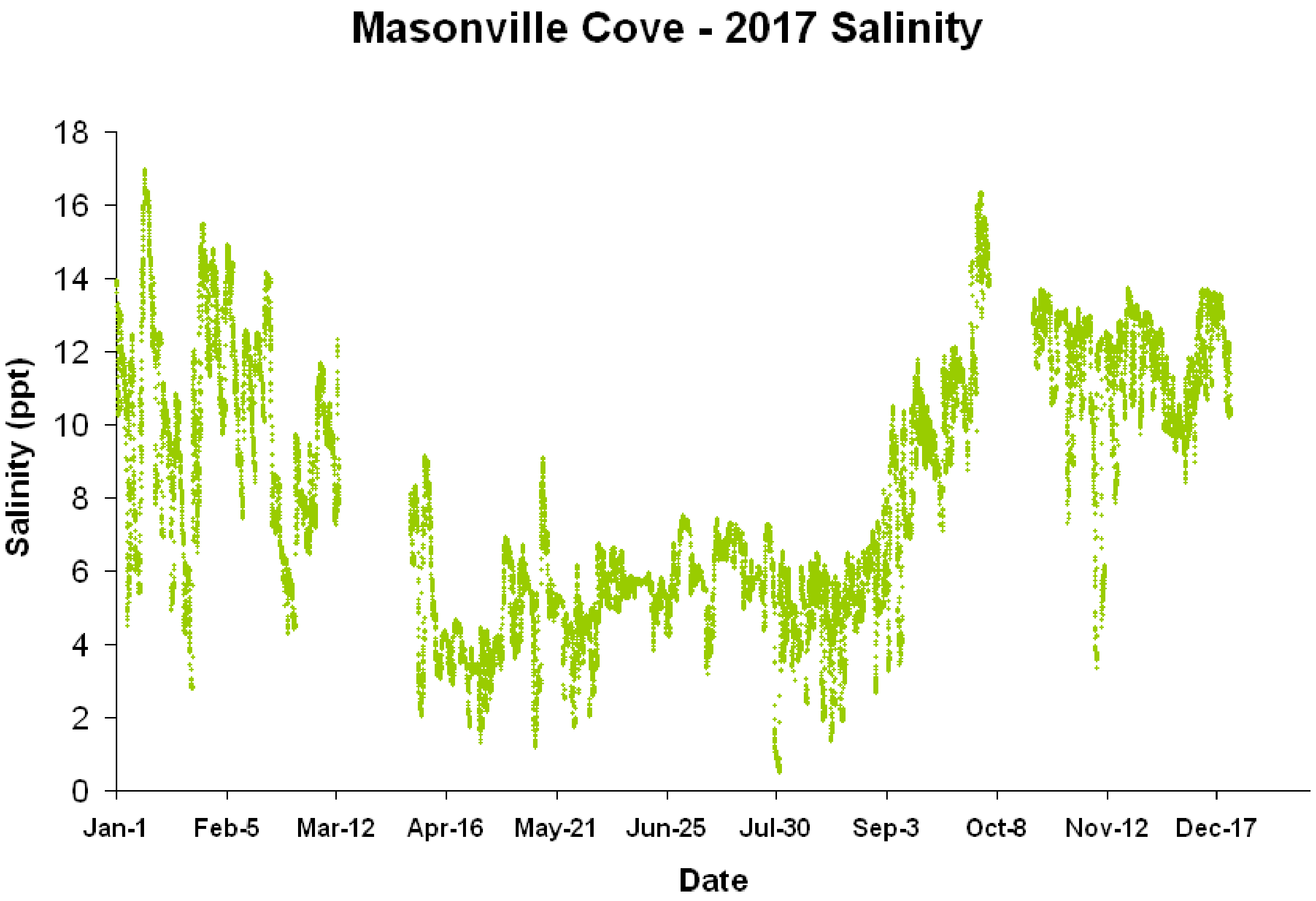

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2017.

Dissolved Oxygen

Dissolved oxygen (DO) values remained high through most of the spring and early summer in 2017 (Figure 7). Peaks to > 20 mg/L in late February and mid-May coincided with the presence of algal bloom conditions (Figure 8) within Masonville Cove. DO concentrations can become super-saturated 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.

Oxygen levels then dropped midway through June and exhibited large swings in concentrations for much of the summer, 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 gradually increased again in the fall and early winter, with peaks in late September (> 17 mg/L) and early December (> 21 mg/L) coinciding with bloom conditions (Figure 8). The summer decrease and fall 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 mid-June and early October may be indicative of algal bloom conditions in Masonville Cove during this time period (Figure 8).

Decreases in chlorophyll levels 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 drops in chlorophyll levels (Figure 8) on May 3rd (3.07 mg/L), June 19th (1.17 mg/L), August 2nd (0.57 mg/L) and the lowest DO reading of the year on September 29th (0.31 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." 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. After three years of worsening DO conditions, DO failure rates decreased in 2017 (Table 1). Concentrations were below 5 mg/L a quarter of the time and below 3.2 mg/L for approximately one-eighth of all readings. Both the 3.2 mg/L and 5 mg/L failure rates were slightly higher than the average failure rate over the prior 8-years of monitoring (11.7% for 3.2 mg/L; 25.4% for 5 mg/L). Most of these low DO readings in 2017 occurred between June and September, which were the four warmest months of the year.

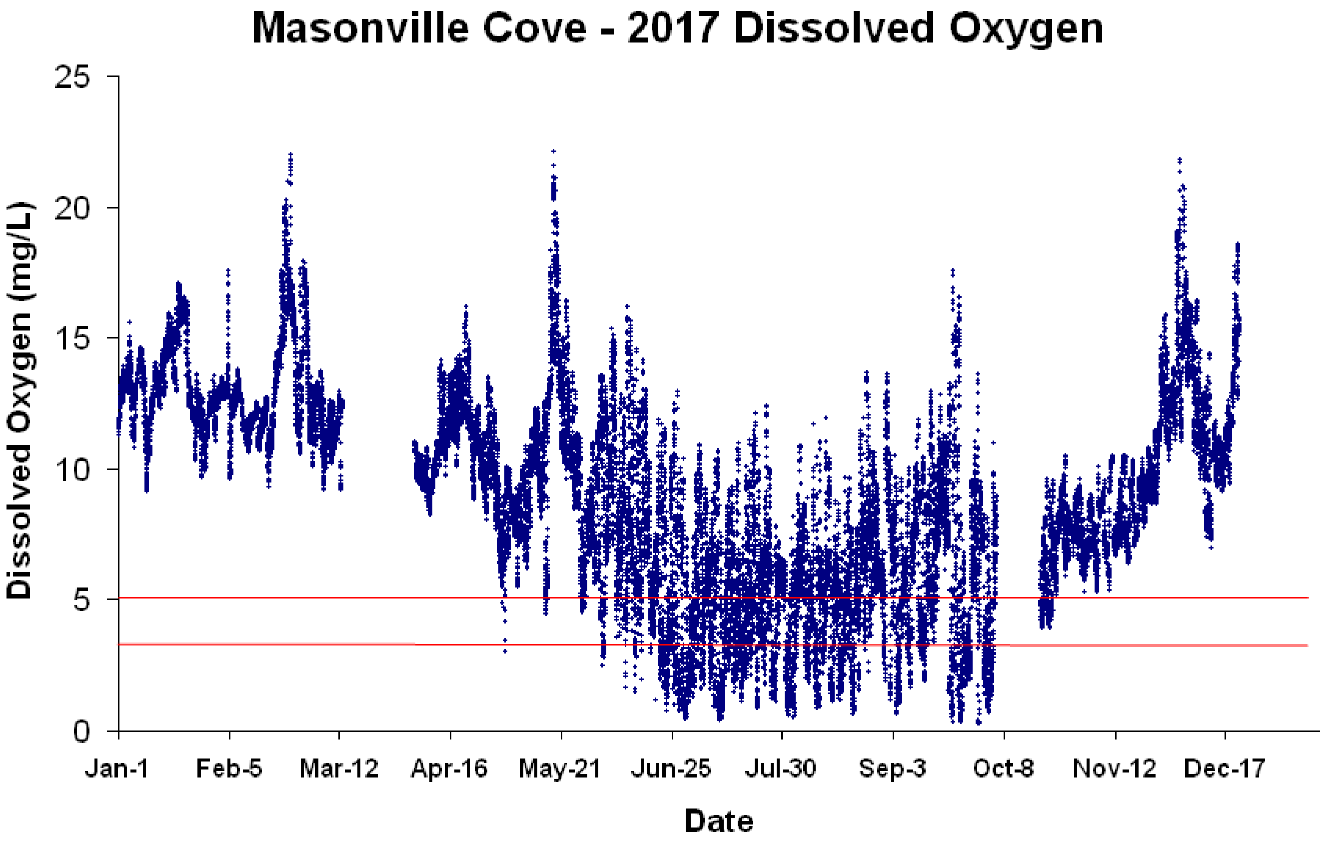

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2017. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

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 2017.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	**2017**
Surface									
Dissolved Oxygen less than 5 mg/L	28.29%	20.02%	14.32%	30.59%	26.01%	24.88%	26.38%	32.97%	**26.22%**
Dissolved Oxygen less than 3.2 mg/L	9.89%	8.61%	8.17%	14.20%	11.73%	8.81%	13.49%	18.97%	**13.38%**

Chlorophyll

Chlorophyll concentrations tend to vary with and are an indicator of, algal (phytoplankton) levels. Peaks 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. At Masonville Cove, chlorophyll readings indicate numerous significant or severe algal blooms occurred in 2017 (Figure 8). The highest chlorophyll readings occurred in late February (434.6 µg/L), late May (141.4 µg/L), early June (155.7 µg/L), late September (166.8 µg/L), late November (111.3 µg/L) and early December (500 µg/L). Samples collected by DNR biologists from Baltimore Harbor during the February bloom indicated the presence of cryptomonads and the potentially harmful algal species *Heterocapsa*. In Masonville Cove, dissolved oxygen concentrations were also super-saturated (Figure 7) and pH was elevated (Figure 10) during this time, further indicating the presence of a large bloom.

In late November, satellite images indicated algal bloom conditions extending from the mainstem Chesapeake Bay to the upper Patapsco (Figure 9). Water samples collected by DNR biologists on November 28th near the mouth of the Patapsco River contained high levels of the potentially harmful algal species *Prorocentrum minimum* (16-67 million cells/L) and *Heterocapsa rotundata* (22-75 million cells/L). Additional samples collected from the Patapsco by the Maryland Department of the Environment on December 6th and December 19th also contained high levels of *P. minimum* (53-153 million cells/L) and *H. rotundata* (11-19 million cells/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 2017 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 2017, chlorophyll levels exceeded the 15 µg/L and 50 µg/L thresholds during 46% and 5.5% of the readings respectively (Table 2). Both rates increased from 2016 readings and were approximately equal to the average rates over the prior eight years (45% for 15 µg/L; 6.7% for 50 µg/L).

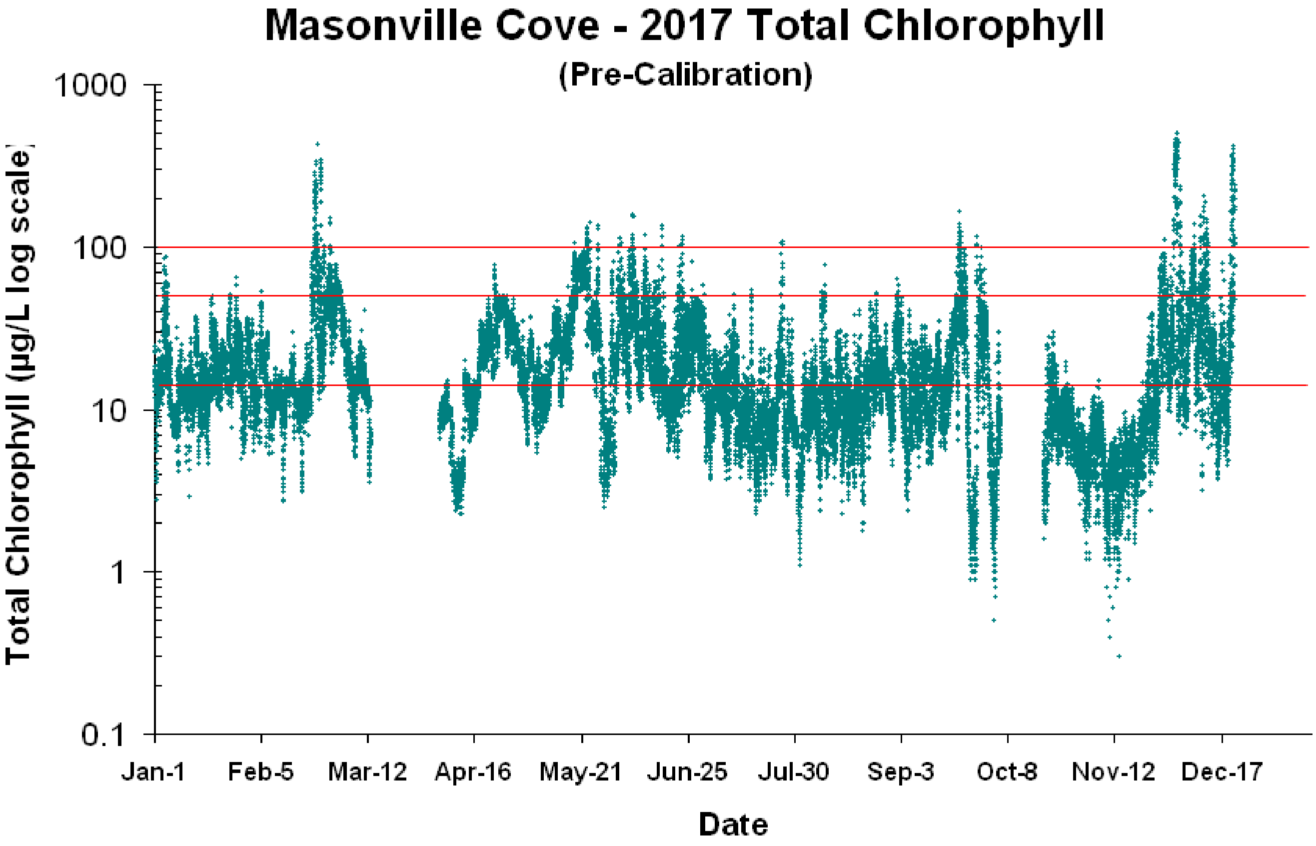

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2017. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 mg/L—are considered significant blooms—50 mg/L—or are considered severe blooms—100 mg/L.)*

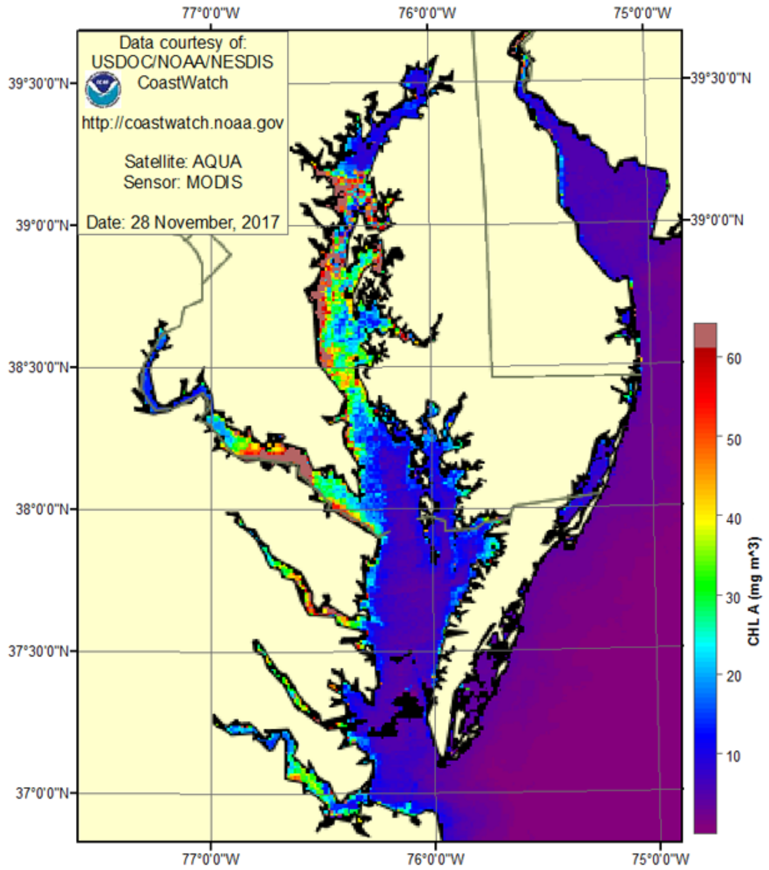

Figure 9. Satellite map from November 28, 2017 of chlorophyll *a* concentrations within the Chesapeake Bay and associated tributaries. Map courtesy of NOAA CoastWatch, East Coast Node (coastwatch.chesapeakebay.noaa.gov/).

Table 2. Chlorophyll threshold failure at Masonville Cove Continuous Monitor during June through November, 2009 and March through October, 2010 to 2017.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	**2017**
Surface									
Readings greater than 15 µg/L	37.37%	58.99%	38.78%	55.63%	52.12%	36.24%	43.11%	40.14%	**46.36%**
Readings greater than 50 µg/L	3.28%	6.58%	0.87%	14.52%	10.50%	5.24%	8.89%	3.97%	**5.53%**

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). At Masonville Cove, 427 pH values exceeded a value of 9 in 2017 (Figure 10). Based on chlorophyll readings (Figure 8), all of these high pH values occurred during significant and severe algal blooms in late February, late May, mid-June, late September and early December. The highest pH value of the year (9.44) was recorded on May 18th. These elevated pH values then tended to decline toward neutral values as chlorophyll concentrations also declined.

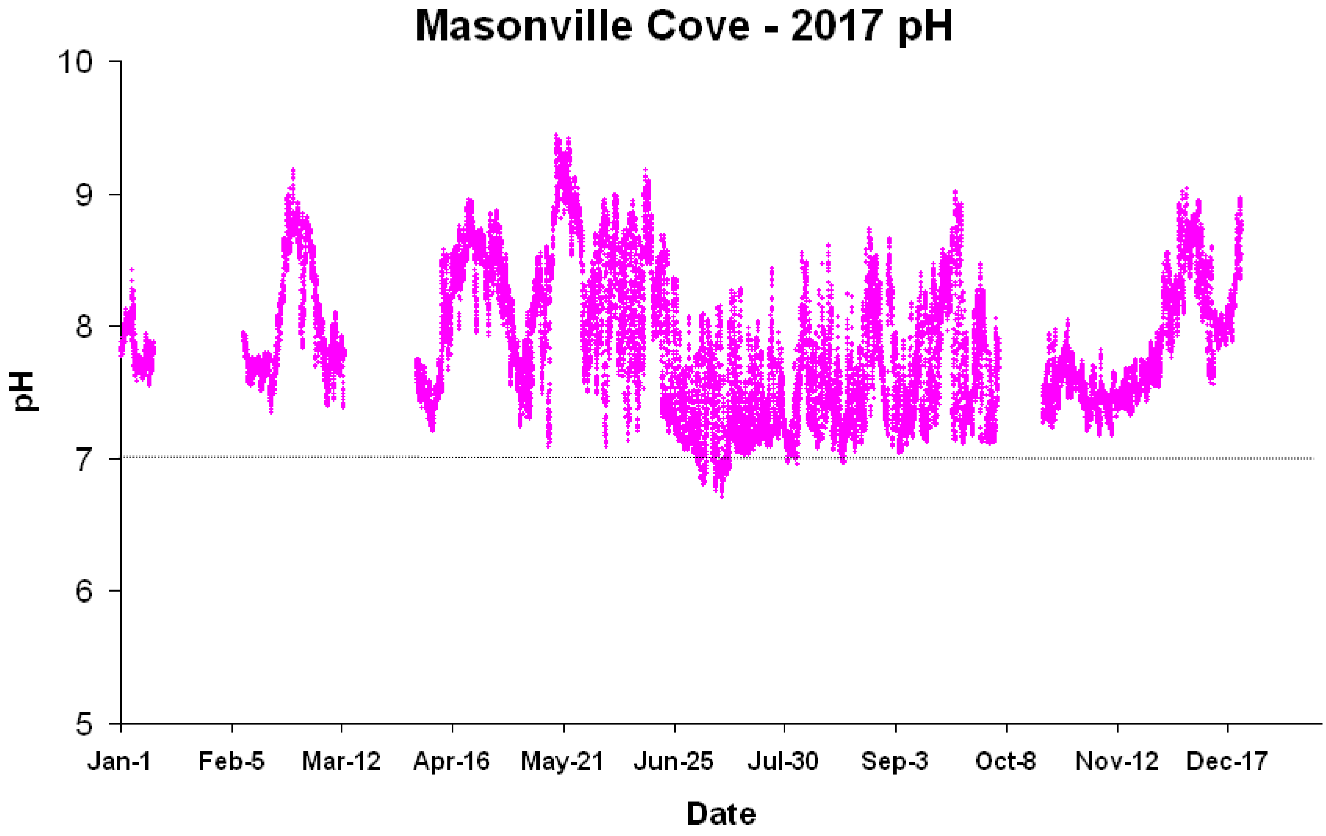

Figure 10. pH levels at Masonville Cove Continuous Monitor during 2017. *(Line indicates neutral pH.)*

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 11) 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 (56%) of turbidity values throughout the year were at or below 7 NTU (median value: 6.2 NTU).

On April 6th, approximately 1.5 inches of rain fell in Central Maryland, leading to a large discharge event (Figure 4). Due to heavy rains overwhelming sanitary lines, several sanitary sewer overflows into the Patapsco River and associated tributaries were reported by the Baltimore City and Baltimore County Departments of Public Works. An estimated 1.3 million gallons of untreated, diluted wastewater were spilled into the watershed during these overflows. As a result of the storm and associated discharge event, turbidity levels at Masonville Cove spiked from approximately 8 NTU on April 5th, prior to the rain, to 112 NTU on April 7th. Turbidity readings then remained elevated through April 8th.

In late July, approximately four inches of rain fell on the region on the 28th and 29th. Sanitary sewer overflows associated with these rains spilled over 8 million gallons of untreated, diluted wastewater in the watershed. Turbidity increased from approximately 5 NTU on July 28th to 127 NTU, the highest value of the year, on July 29th. The high turbidity readings during both of these events indicate that water discharged into the river brought high concentrations of particles and sediment that clouded the water.

Interspersed with some brief spikes, turbidity values generally remained below 7 NTU for the last four months of 2017. This may have been the result of the rainfall deficit (Figure 3) and low flows (Figure 4) during this time period.

Turbidity measurements above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. Although the majority of turbidity values in Masonville Cove were at or below 7 NTU in 2017, almost 61% of turbidity values during the SAV growing season (March through October) were above this threshold (Table 3). This failure rate was well above the average of the prior eight years (49.6%) and was the highest since monitoring began in Masonville Cove in 2009. Thus, water clarity conditions in Masonville Cove in 2017, during the seasons most important to SAV growth, were considered poor.

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

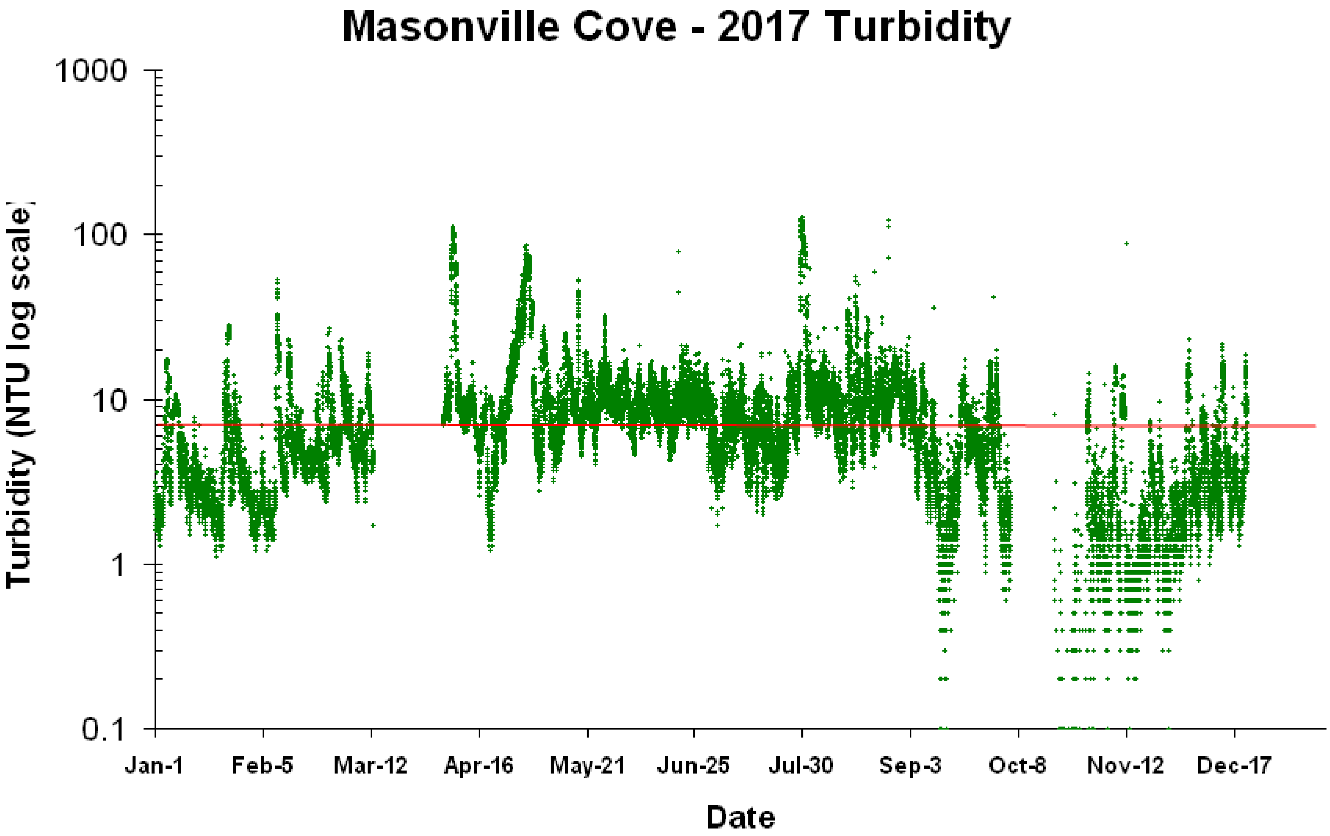

Figure 11. Turbidity levels at Masonville Cove Continuous Monitor during 2017. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failure at Masonville Cove Continuous Monitor during June through December, 2009 and March through October, 2010 to 2017.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	**2017**
Surface									
Readings greater than 7 NTU	54.58%	60.09%	51.58%	35.0%	53.91%	52.92%	53.82%	34.91%	**60.87%**

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 12 shows total area and density of SAV within the Patapsco beginning in 1994 (the first year SAV was found in the river) through 2017.

Total area of SAV within the Patapsco River remains well below the restoration goal of 389 acres. 2005 was the single best year with 72% of the restoration goal 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. As of 2017, approximately 14 acres of SAV were observed in the Patapsco River, most near the river’s mouth, and no SAV was found within Masonville Cove. This total area represents a 400% increase from 2016 and is approximately 4% of the river’s restoration goal.

This increase in SAV coverage in the Patapsco River follows the recent trends seen throughout the Chesapeake Bay watershed. Many tributaries have seem record expansions of SAV beds over the past few years and bay-wide, SAV coverage exceeded 100,000 acres in 2017 for the first time since annual assessments began. Poor water clarity and lack of viable seed banks may explain the lack of SAV coverage within Masonville Cove.

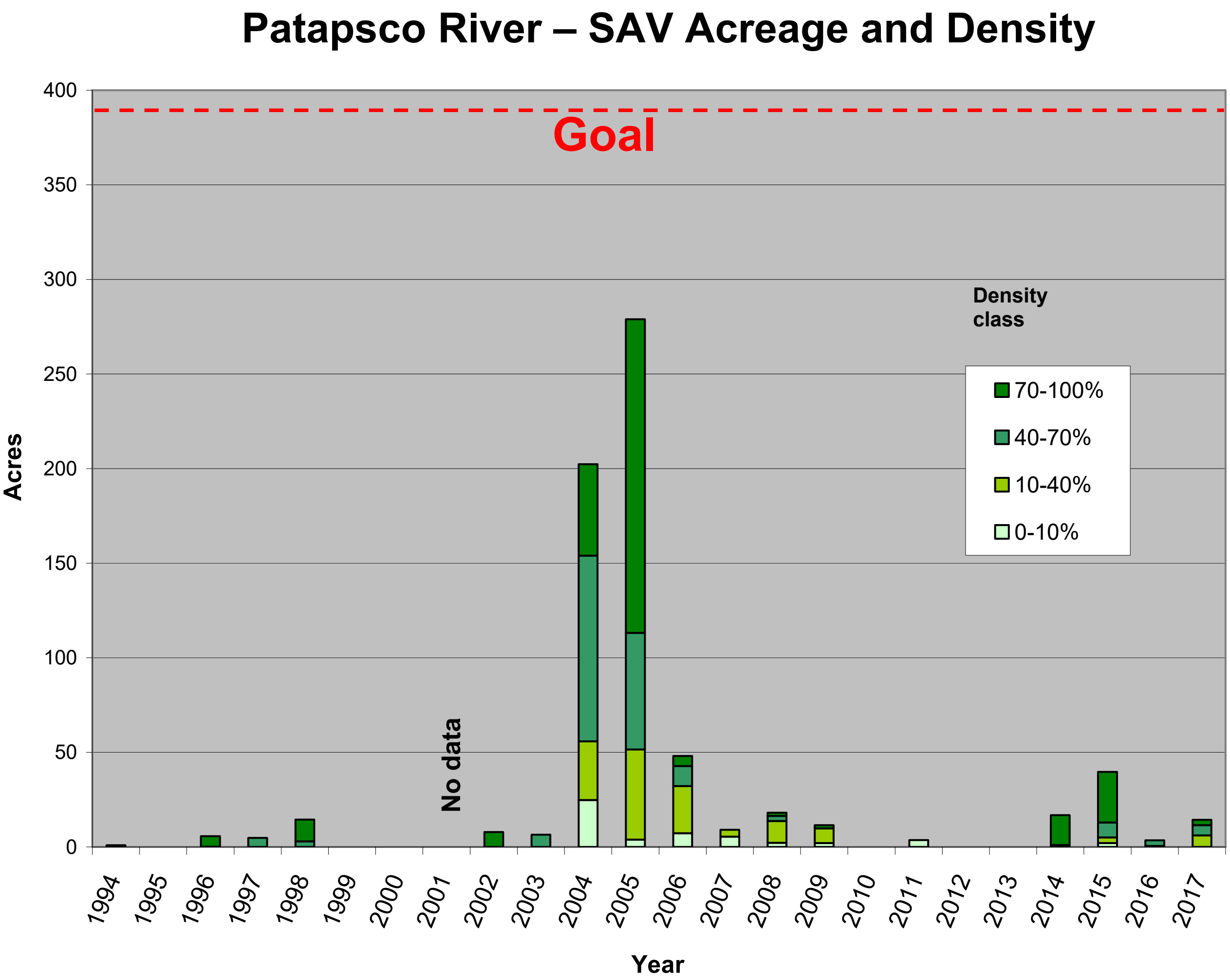

Figure 12. Total area and density of SAV in the Patapsco River between 1994 and 2017. (*Restoration goal is 389 acres)*

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: eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/SWM_QAPP_2017_2018_Draft_v6.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. Note that on January 11, 2017, the field crew reported thick ice at the station and did not collect a Secchi depth reading.

Pigments

As previously noted, chlorophyll concentrations in excess of 50 µg/l may be indicative of a significant algal bloom. At Masonville Cove in 2017, chlorophyll concentrations exceeded the 50 mg/l threshold on two sampling dates: first on May 18 (81.2 µg/l) and then on August 24 (92.1 µg/l) (Figure A-1). The August 24 chlorophyll value was the highest in 2017. Chlorophyll values were below the 50 µg/l threshold for all other sample dates, however, values approaching the 50 µg/l threshold occurred in April, July and September. Pheophytin values around 10 µg/l were frequently observed at Masonville Cove during the months of May through September 2017 (Figure A-2). For all other months, pheophytin values remained below 5 µg/l.

Suspended Solids

Concentrations of suspended solids at Masonville Cove were below 10 mg/l during the winter months of January through March 2017 (Figure A-3). With the onset of rainy weather in April, suspended solids concentrations rose steadily, increasing to a peak value of 40 mg/l on June 29, 2017. Drier weather in the month of June caused the suspended solids value to decrease on July 12, but concentrations rose again with the return of heavy rains in July and August. For October through December, suspended solids concentrations returned once again to values below 10 mg/l.

Secchi Depths

Secchi depths show an inverse relationship to suspended solids concentrations. During the months of April through September, as heavy rain events increased freshwater input and decreased water clarity, Secchi depths declined. Secchi depths were generally less than 0.6 m during this period (Figure A-4). A slightly greater Secchi depth was observed on the July 12 sampling date following a relatively dry period during the month of June. Outside of the April-September time period, Secchi depths ranged between 0.8-1.2 m.

Table 4. Deployment and calibration record for Masonville Cove continuous monitor in 2017.

Scheduled calibration date	Samples collected	Comment
January 11, 2017	Yes	Surface ice; no Secchi reading.
February 8, 2017	Yes	
March 9, 2017	Yes	
April 4, 2017	Yes	
April 18, 2017	Yes	
May 3, 2017	Yes	
May 17, 2017	Yes	
June 1, 2017	Yes	
June 15, 2017	Yes	
June 29, 2017	Yes	
July 12, 2017	Yes	
July 25, 2017	Yes	
August 10, 2017	Yes	
August 24, 2017	Yes	
September 6, 2017	Yes	
September 19, 2017	Yes	
October 5, 2017	Yes	
October 19, 2017	Yes	Site not visited due to scheduling conflict.
November 1, 2017	Yes	
December 11, 2017	Yes	

Ambient Water Quality

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

Salinity concentrations at Masonville Cove were closely correlated to precipitation patterns in 2017. Early (January through March) and late (October through December) in the year, salinity concentrations ranged from 8.5 ppt to 15.8 ppt. Heavy rains during the spring and summer (April through September) caused a general decline in salinity to values less than 7 ppt (Figure A-5). Drier weather during the month of June resulted in slightly higher salinity values observed during the July 12 service visit.

Dissolved oxygen

Dissolved oxygen concentrations at Masonville Cove generally ranged between 5 mg/l and 13 mg/l throughout 2017 (Figure A-6). Concentrations were lower during the summer months, with values less than 5 mg/l occasionally measured in the bottom waters during June, July, August and October. Summer dissolved oxygen values also showed the most pronounced differences between surface water and bottom water measurements. Summer surface water oxygen values were often higher than bottom water values by as much as 4 mg/l or more. Unusually high values of dissolved oxygen (14.5-16.8 mg/l) on May 18 correspond to high chlorophyll concentrations (>80 µg/l) also observed on this date and may be the result of increased photosynthetic activity during an algal bloom. As further evidence of bloom conditions, a peak pH value of 9.1 also occurred on May 18, 2017.

Water Temperature and pH

Water temperature varied seasonally at Masonville Cove, beginning with a low measurement of 3.0 °C on January 11, gradually rising to a peak of 27.9 °C on July 25 and then falling slowly to around 8 °C on December 11 (Figure A-7). Other than the peak pH value on May 18, pH values at Masonville Cove generally fluctuated between 7.5 and 8.5 throughout 2017 (Figure A-8).

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2017. 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 2017, heavy rains in April and July led to massive discharge events that affected salinity and water clarity. Significant to severe algal bloom conditions occurred several times in 2017 and potentially harmful algal species *Heterocapsa rotundata* and *Prorocentrum minimum* were observed in the Patapsco River in February and in November/December. Dissolved oxygen concentrations were low for much of the summer and early fall and turbidity measurements indicated the lowest water clarity in Masonville Cove since monitoring began in 2009. Finally, as of 2017, no submerged aquatic vegetation was found in Masonville Cove. Therefore, 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). mdsg.umd.edu/MarineNotes/Mar-Apr01/

Appendix A

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

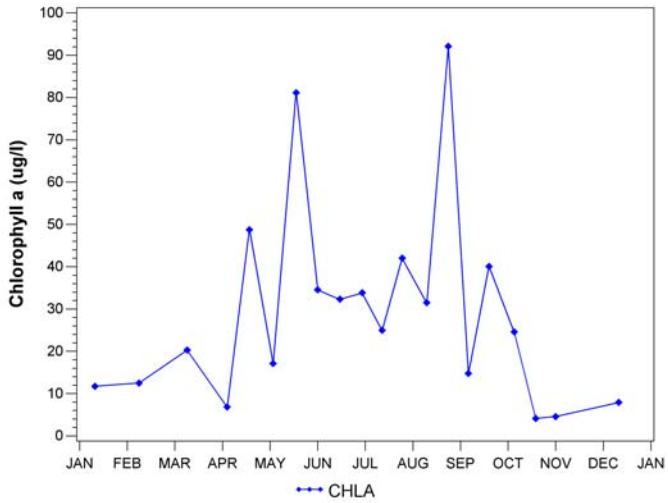

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2017.

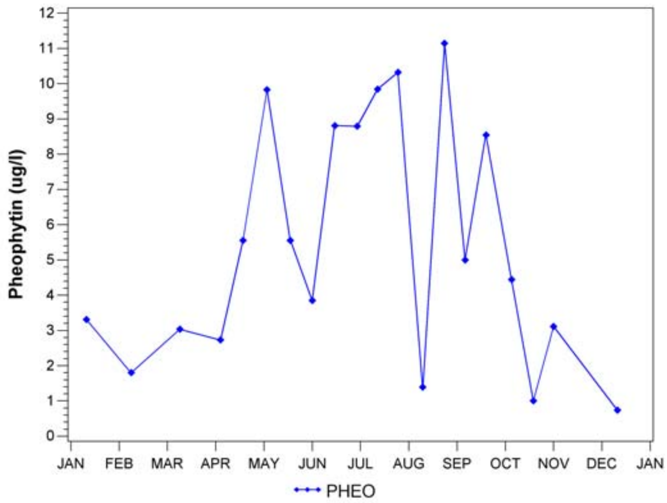

Figure A-2. Pheophytin concentrations at Masonville Cove in 2017.

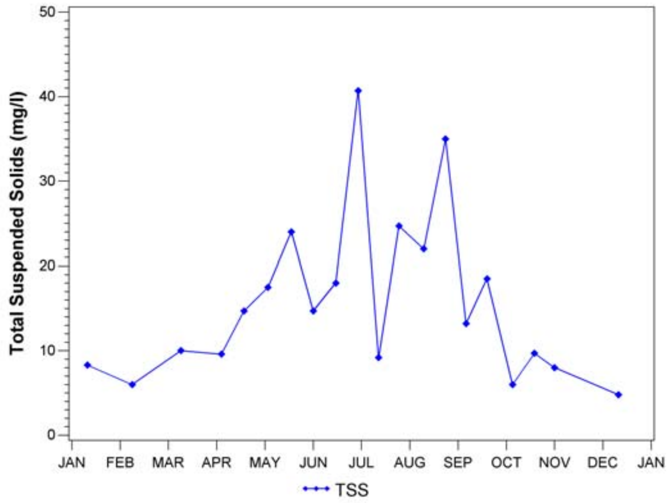

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2017.

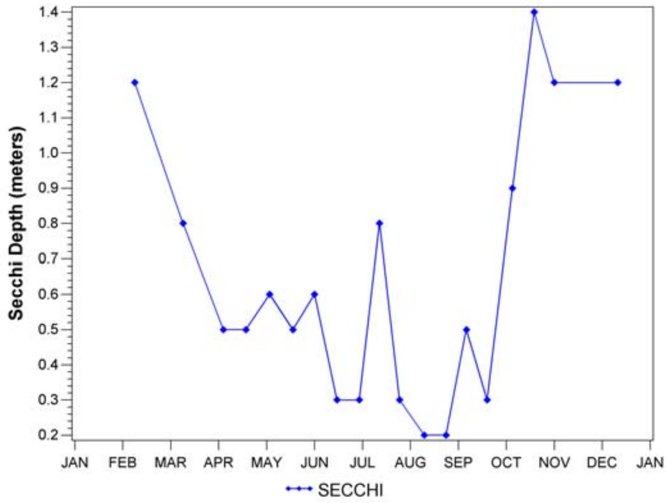

Figure A-4. Secchi depth at Masonville Cove in 2017.

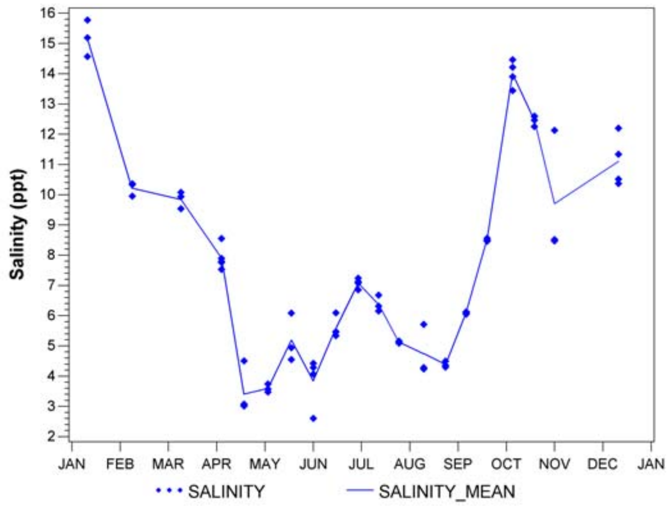

Figure A-5. Salinity concentrations at Masonville Cove in 2017.

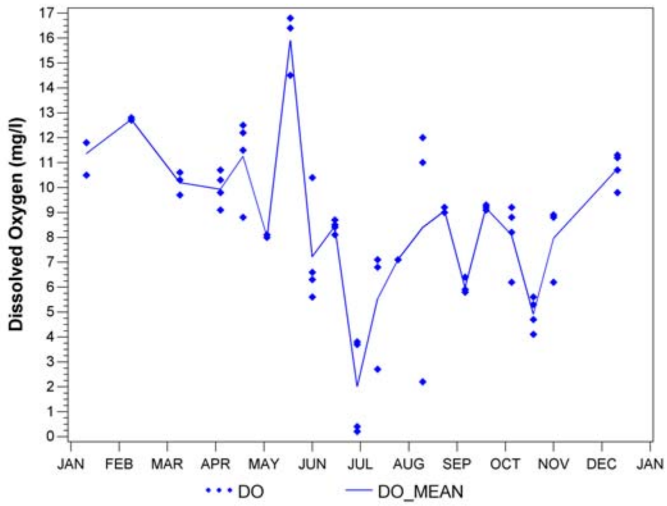

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2017.

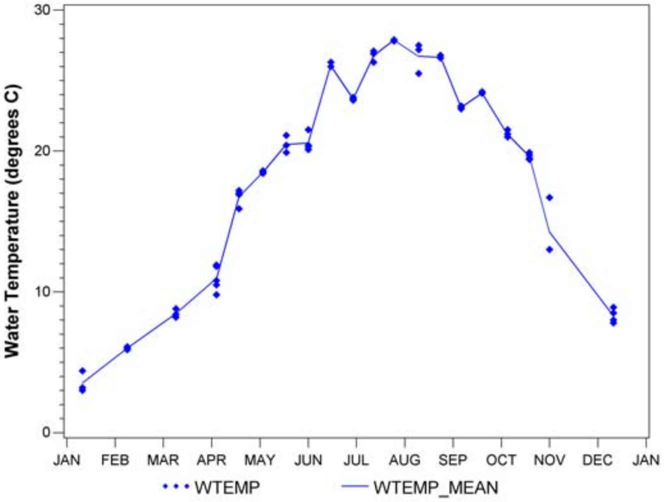

Figure A-7. Water temperature at Masonville Cove in 2017.

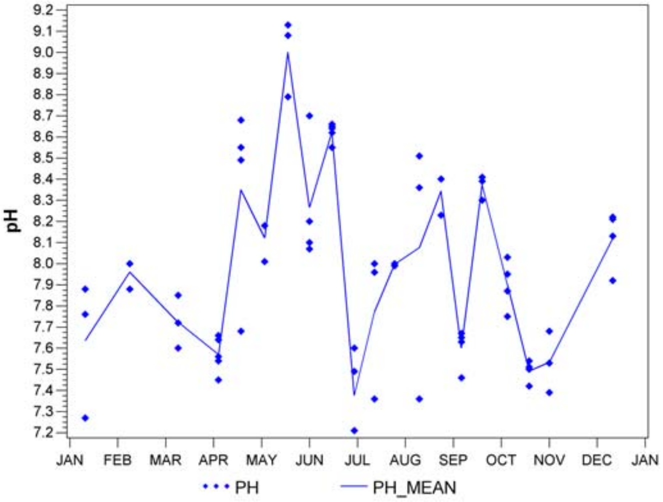

Figure A-8. Values of pH at Masonville Cove in 2017.

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 2017.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Pheophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
01/11/17	1	11.748	3.311	8.3	No data
02/08/17	1	12.511	1.800	6.0	1.2
03/09/17	1	20.292	3.033	10.0	0.8
04/04/17	1	6.835	2.734	9.6	0.5
04/18/17	1	48.772	5.554	14.7	0.5
05/03/17	1	17.088	9.826	17.5	0.6
05/18/17	1	81.168	5.554	24.0	0.5
06/01/17	1	34.532	3.845	14.7	0.6
06/15/17	1	32.307	8.811	18.0	0.3
06/29/17	1	33.820	8.793	40.7	0.3
07/12/17	1	24.991	9.847	9.2	0.8
07/25/17	1	42.008	10.324	24.7	0.3
08/10/17	1	31.506	1.388	22.0	0.2
08/24/17	1	92.115	11.147	35.0	0.2
09/06/17	1	14.738	4.998	13.2	0.5
09/19/17	1	40.050	8.544	18.5	0.3
10/05/17	1	24.564	4.443	6.0	0.9
10/19/17	1	4.119	1.007	9.7	1.4
11/01/17	1	4.577	3.112	8.0	1.2
12/11/17	1	7.934	<0.740	4.8	1.2

Table A-2. Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity and Water Temperature for Masonville Cove (XIE4742) in 2017 (continued on next page).

Date	Sample Depth (m)	D. O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
01/11/17	0.5	11.8	7.88	14.57	3.2
01/11/17	1.0	11.8	7.27	15.19	3.0
01/11/17	1.7	10.5	7.76	15.77	4.4
02/08/17	0.5	12.8	8.00	9.95	6.1
02/08/17	1.0	12.7	7.88	10.33	6.0
02/08/17	1.6	12.7	8.00	10.36	5.9
03/09/17	0.5	10.3	7.85	9.53	8.8
03/09/17	1.0	10.6	7.60	10.08	8.4
03/09/17	1.5	9.7	7.72	9.93	8.2
04/04/17	0.5	10.3	7.66	7.53	11.8
04/04/17	1.0	10.7	7.64	7.76	11.9
04/04/17	1.5	9.8	7.56	7.79	10.8
04/04/17	2.0	9.8	7.54	7.89	10.5
04/04/17	2.4	9.1	7.45	8.55	9.8
04/18/17	0.5	12.5	8.68	3.01	17.2
04/18/17	1.0	12.2	8.49	3.07	17.0
04/18/17	1.5	11.5	8.55	3.03	16.9
04/18/17	2.0	8.8	7.68	4.50	15.9
05/03/17	0.5	8.1	8.18	3.47	18.6
05/03/17	1.0	8.0	8.01	3.57	18.4
05/03/17	1.5	8.0	8.18	3.74	18.5
05/18/17	0.5	16.4	9.13	4.55	21.1
05/18/17	1.0	16.8	9.08	4.94	20.4
05/18/17	2.0	14.5	8.79	6.08	19.9
06/01/17	0.5	10.4	8.70	2.60	21.5
06/01/17	1.0	6.6	8.07	4.07	20.4
06/01/17	1.5	6.3	8.20	4.28	20.3
06/01/17	2.1	5.6	8.10	4.42	20.1
06/15/17	0.5	8.7	8.66	6.09	26.3
06/15/17	1.0	8.5	8.55	5.34	26.0
06/15/17	1.5	8.4	8.64	5.46	26.0
06/15/17	2.0	8.5	8.65	5.47	26.0
06/15/17	2.3	8.1	8.62	5.47	26.0
06/29/17	0.5	3.7	7.49	6.85	23.8
06/29/17	1.0	3.8	7.60	7.08	23.6
06/29/17	2.0	0.4	7.21	7.12	23.7
06/29/17	2.2	0.2	7.21	7.24	23.8

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity and Water Temperature for Masonville Cove (XIE4742) in 2017.

Date	Sample Depth (m)	D. O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
07/12/17	0.5	6.8	8.00	6.15	27.1
07/12/17	1.0	7.1	7.96	6.31	26.9
07/12/17	2.0	2.7	7.36	6.68	26.3
07/25/17	0.5	7.1	8.00	5.09	27.9
07/25/17	1.0	7.1	7.99	5.16	27.8
07/25/17	1.5	7.1	8.00	5.11	27.9
07/25/17	2.1	7.1	8.00	5.16	27.9
08/10/17	0.5	12.0	8.51	4.24	27.5
08/10/17	1.0	11.0	8.36	4.28	27.2
08/10/17	1.7	2.2	7.36	5.71	25.5
08/24/17	0.5	9.2	8.40	4.30	26.8
08/24/17	1.0	9.0	8.23	4.49	26.6
08/24/17	1.9	9.0	8.40	4.36	26.6
09/06/17	0.5	5.8	7.67	6.05	23.1
09/06/17	1.0	6.4	7.46	6.10	23.0
09/06/17	1.5	5.9	7.63	6.12	23.2
09/06/17	1.8	5.8	7.65	6.13	23.1
09/19/17	0.5	9.3	8.41	8.46	24.2
09/19/17	1.0	9.1	8.30	8.50	24.1
09/19/17	1.5	9.2	8.39	8.49	24.1
09/19/17	1.9	9.1	8.39	8.56	24.1
10/05/17	0.5	9.2	8.03	13.44	21.0
10/05/17	1.0	8.8	7.87	13.90	21.2
10/05/17	1.5	8.2	7.95	14.21	21.0
10/05/17	2.1	6.2	7.75	14.46	21.5
10/19/17	0.5	5.3	7.50	12.25	19.5
10/19/17	1.0	5.6	7.42	12.59	19.4
10/19/17	1.5	4.7	7.51	12.46	19.7
10/19/17	1.9	4.1	7.54	12.60	19.9
11/01/17	0.5	8.8	7.68	8.47	13.0
11/01/17	1.0	8.9	7.39	8.51	13.0
11/01/17	1.5	6.2	7.53	12.13	16.7
12/11/17	0.5	11.3	8.22	10.37	8.0
12/11/17	1.0	10.7	8.13	10.51	7.8
12/11/17	1.5	11.2	8.21	11.34	8.5
12/11/17	2.0	9.8	7.92	12.20	8.9