MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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2023 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

February 2025

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Wes Moore, Governor

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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 some 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 2022.

Results from 2023 indicate slight improvements in water quality but continuing poor habitat conditions in Masonville Cove. Dissolved oxygen concentrations improved from 2022 but remained below long-term averages. Algal conditions also improved slightly and water clarity conditions were the best since monitoring began in Masonville Cove. However, large data gaps in 2023 may have skewed results and make comparisons to prior years problematic. Together, results indicate that excessive runoff and associated nutrients continue to impair aquatic grass growth within Masonville Cove and are fueling algal blooms and degrading dissolved oxygen levels within the water.

All 2023 continuous monitoring data, as well as data from previous years, are available on the DNR "Eyes on the Bay" website (https://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 (https://eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm). Data collected from the current station location between 2013 and 2023 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: https://datahub.chesapeakebay.net/api.CSV/WaterQuality/WaterQuality/3-27-2013/12-31-2023/0/4/2/Station/1930/21,31,55,60,63,65,71,73,74,76,77,78,82,83,85,88,94,104,105,116,121,123. Data collected at the previous station location between 2009 and 2012 are available for download at: https://datahub.chesapeakebay.net/api.CSV/WaterQuality/WaterQuality/6-3-2009/12-31-2012/0/4/2/Station/1929/21,31,55,60,63,65,71,73,74,76,77,78,82,83,85,88,94,104,105,116,121,123.

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 2023, as a 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 four continuous monitoring stations located in the upper Patapsco in 2023. The other sites were deployed adjacent to the National Aquarium in the Baltimore Harbor and in the Middle Branch of the Patapsco River. Together, these sites provide a comprehensive view of water quality in the upper tidal Patapsco watershed, that can help guide and evaluate restoration actions.

Description of continuous monitoring

In 2023, 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 the 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.

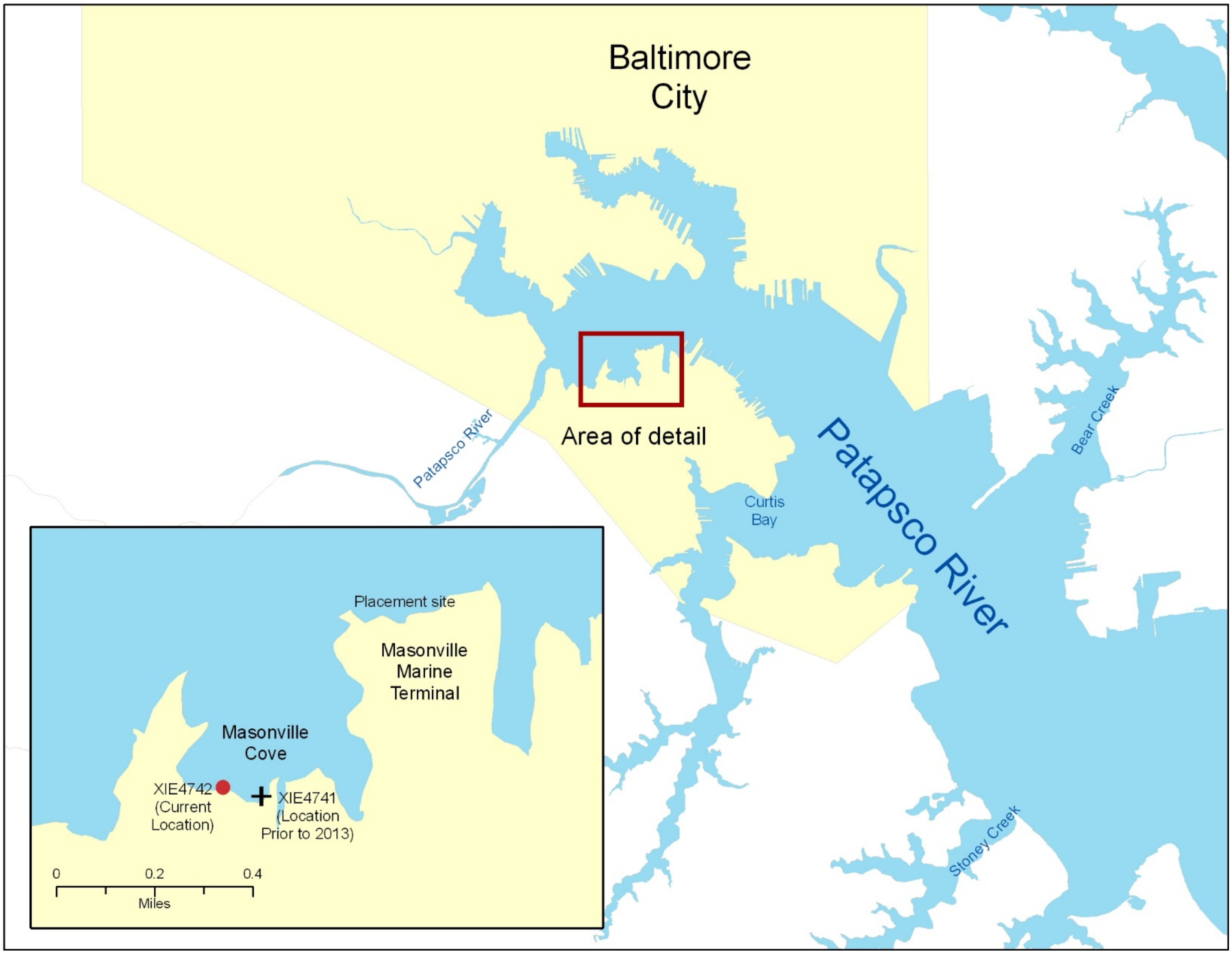

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2023 continuous monitor location within the cove, the location of the monitor prior to 2013, and the approximate site for dredged material placement.

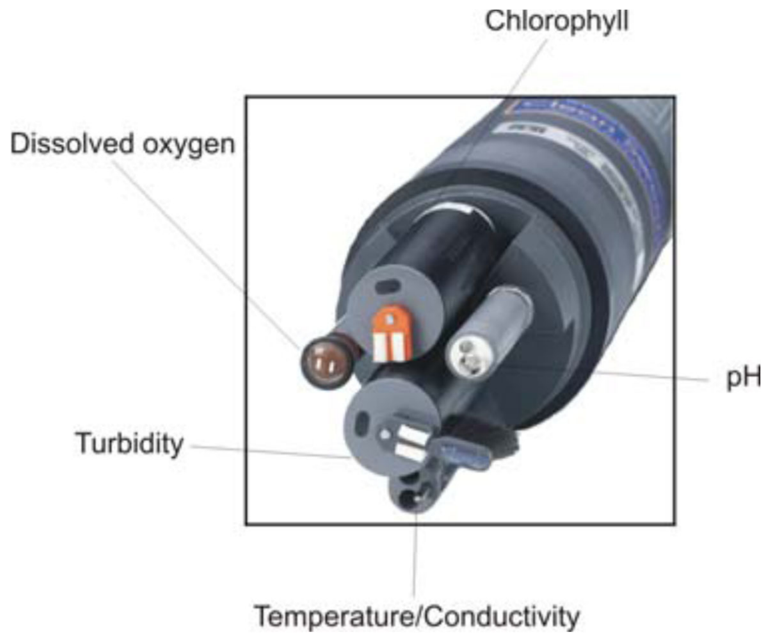

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

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 saxatilis*).
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 the 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 of water over 8 in low salinity).

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 increased turbidity. Relatively clear water (low turbidity) is required for the growth and survival of SAV.
6. Chlorophyll: Chlorophyll concentration is a surrogate measure of the density 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 2023, a continuous monitor at Masonville Cove was deployed for the entire year. Data sondes collected 31,459 data records and 18 calibration samples were collected and analyzed in 2023. Calibration samples were collected when sondes were changed out every two weeks between April and October and every four weeks between November and March.

There were numerous malfunctions to the deployed water quality monitoring sondes that precluded data collection during times in 2023. No water quality monitoring sonde data were collected between January 1st and January 5th, June 20th and June 21st, July 5th and July 15th, September 12th and September 19th, October 4th and October 10th, October 16th and October 17th, October 26th and October 31st, and between December 4th and December 7th. These malfunctions were most likely caused by older YSI model sondes (6600-V2) being deployed in Masonville Cove in 2023. DNR ordered newer YSI model sondes (EXO2) with deployment at the Masonville Cove continuous monitoring station scheduled for 2024.

Additional gaps in 2023 data are where questionable data were removed for quality assurance purposes.

2023 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 2023 at Baltimore Washington International (BWI) Thurgood Marshall Airport was below the long-term norm (Figure 3). Total precipitation was 42.26 inches, which is 2.76 inches below the 30-year average. Total precipitation was below monthly averages in seven of the twelve months with May being the dryest month as only half of an inch of precipitation was recorded. December was the wettest month of the year with 7.16 inches of precipitation (Figure 3). July was the second wettest month of 2023 at 6.84 inches and September was the third wettest at 6.27 inches.

Daily mean discharge at the United States Geological Survey (USGS) gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2023 (Figure 4). Gage data show numerous spikes throughout 2023, which are indicative of the precipitation events that affected the region during the year. The largest flow of the year occurred during the year's wettest month on December 18th. Two-inches of rain fell on the region at that time and the recorded flow rate was more than 1,000 cubic feet per second (cfs) greater than the daily median measured over 59 years, reflecting very high discharge levels into the Patapsco River and the Chesapeake Bay. Extremely high flows of more than 300 cfs greater than the daily median were also measured following heavy rains on September 24th, November 22nd, and December 11th.

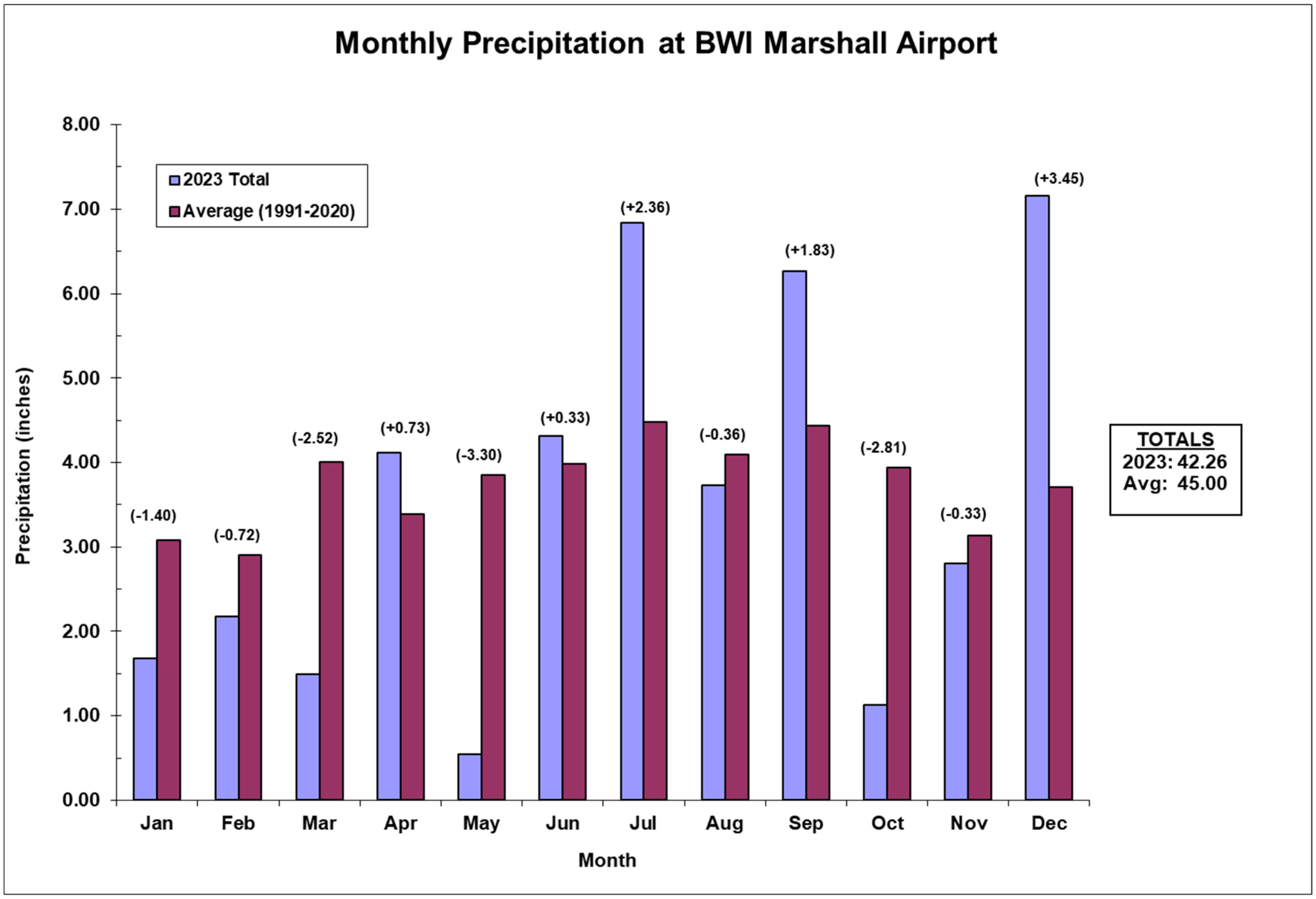

Figure 3. Total 2023 monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages. Data source: National Weather Service (https://www.weather.gov/media/lwx/climate/bwiprecip.pdf).

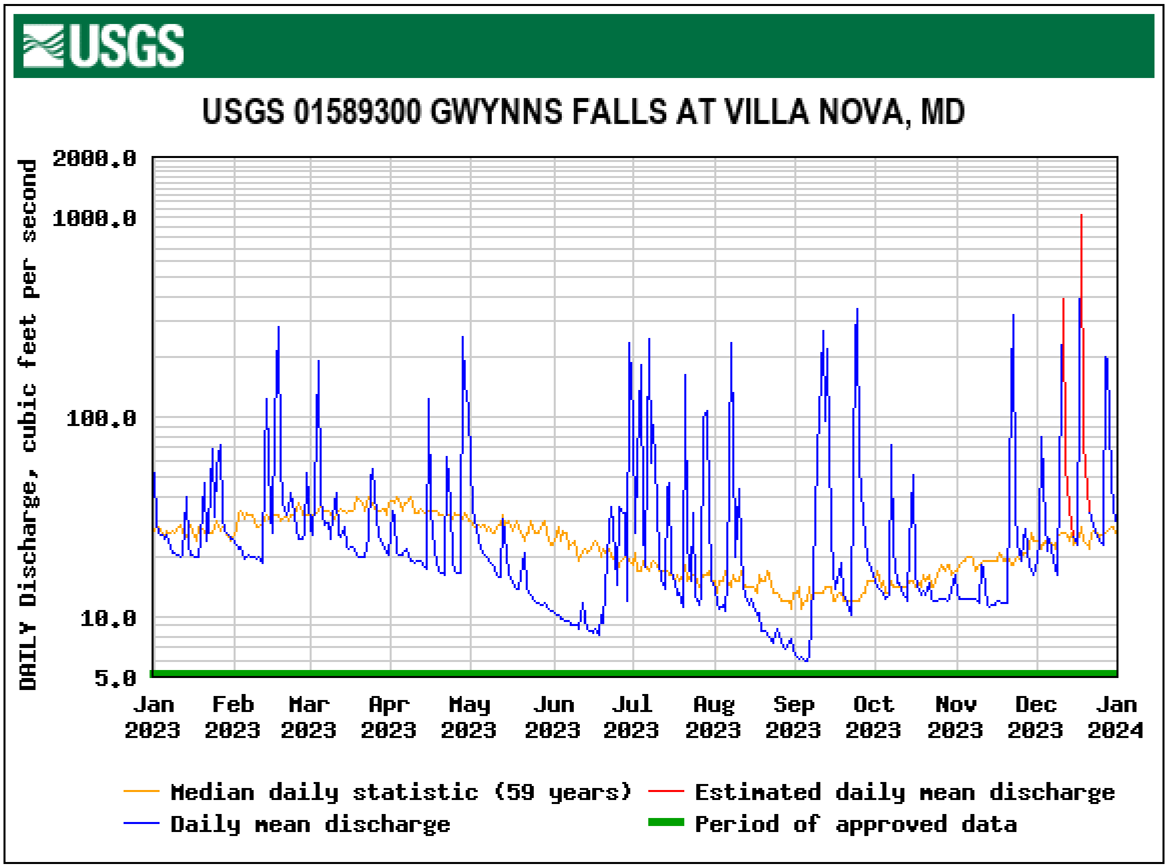

Figure 4. 2023 daily discharge in cubic feet per second measured at a USGS gaging station northwest of Masonville Cove. Graph courtesy of the United States Geological Survey (https://waterdata.usgs.gov/nwis/dv/?site_no=01589300).

2023 Continuous Monitoring Data

Water temperature

Water temperatures at Masonville Cove hovered around 5°C (41º F) during the first few weeks of 2023 and dropped a couple times to near freezing in mid-January and early February (Figure 5). Temperatures then rose predictably during the next several months as air temperatures increased. Heavy rains in early July stunted the increase in water temperatures and they remained relatively steady into mid-September 2023. The highest readings of the year were recorded in late July and early September as water temperatures exceeded 30°C (86º F) during these times. As air temperatures cooled through the rest of the year after mid-September water temperatures followed this pattern and declined to 5-10°C (41-50º F) in late December. 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).

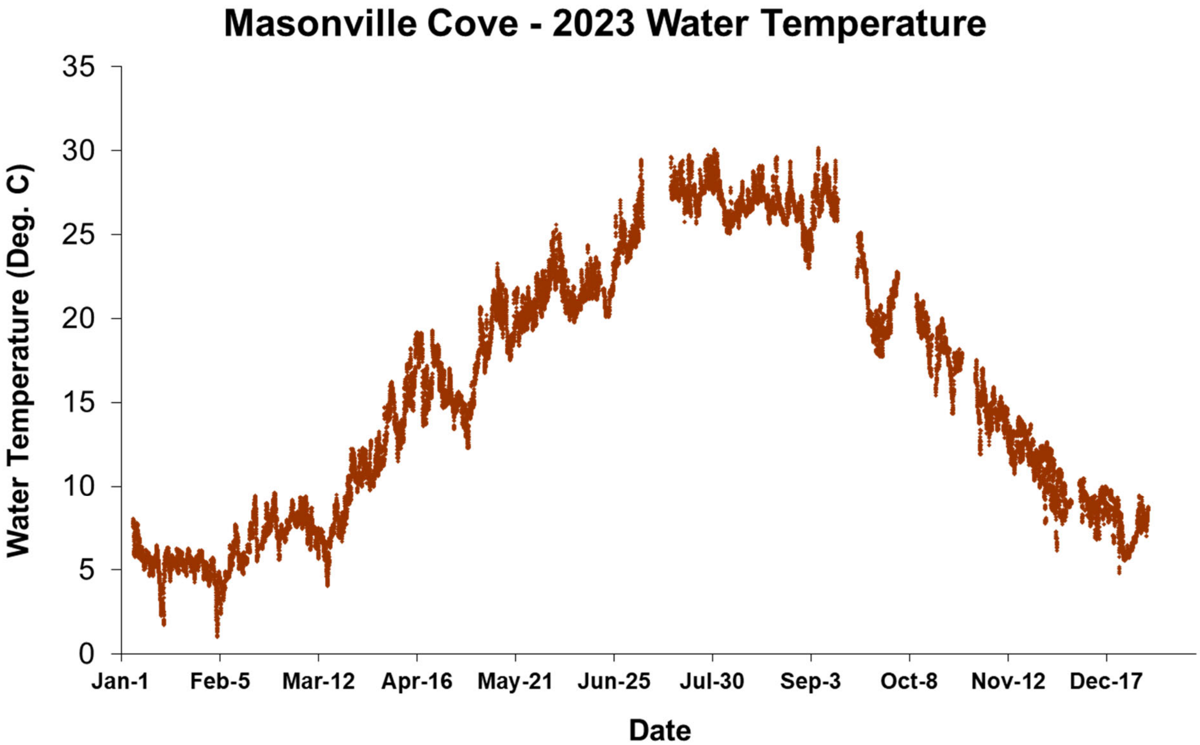

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2023.

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 late fall and early winter. Salinity concentrations were elevated during the first couple months of 2023 and peaked at almost 15 ppt in mid-March before spring rains precipitated a decline in salinity concentrations to less than 10 ppt (Figure 6). Concentrations increased to 12 ppt following a dry May and first couple weeks of June. A wetter than normal July (Figure 3) coincided with a drop in salinity to 10 ppt. Readings then increased to 17.6 ppt during a dryer than normal October (Figure 3). Heavy precipitation events in November and December led to influxes of freshwater, which coincided with drops in salinity concentrations to 3.5 ppt in November and near 0 ppt in late December.

Salinity readings in Masonville Cove often dropped precipitously following rain events, before quickly rebounding to prior levels. This ‘flashiness’ pattern is often observed in urban environments and reflects how quickly flow in a river or stream increases and decreases during a storm. Flashy patterns are common in urbanized areas because stormwater runoff reaches the waterways much more quickly than rural areas due to a higher amount of impervious surfaces.

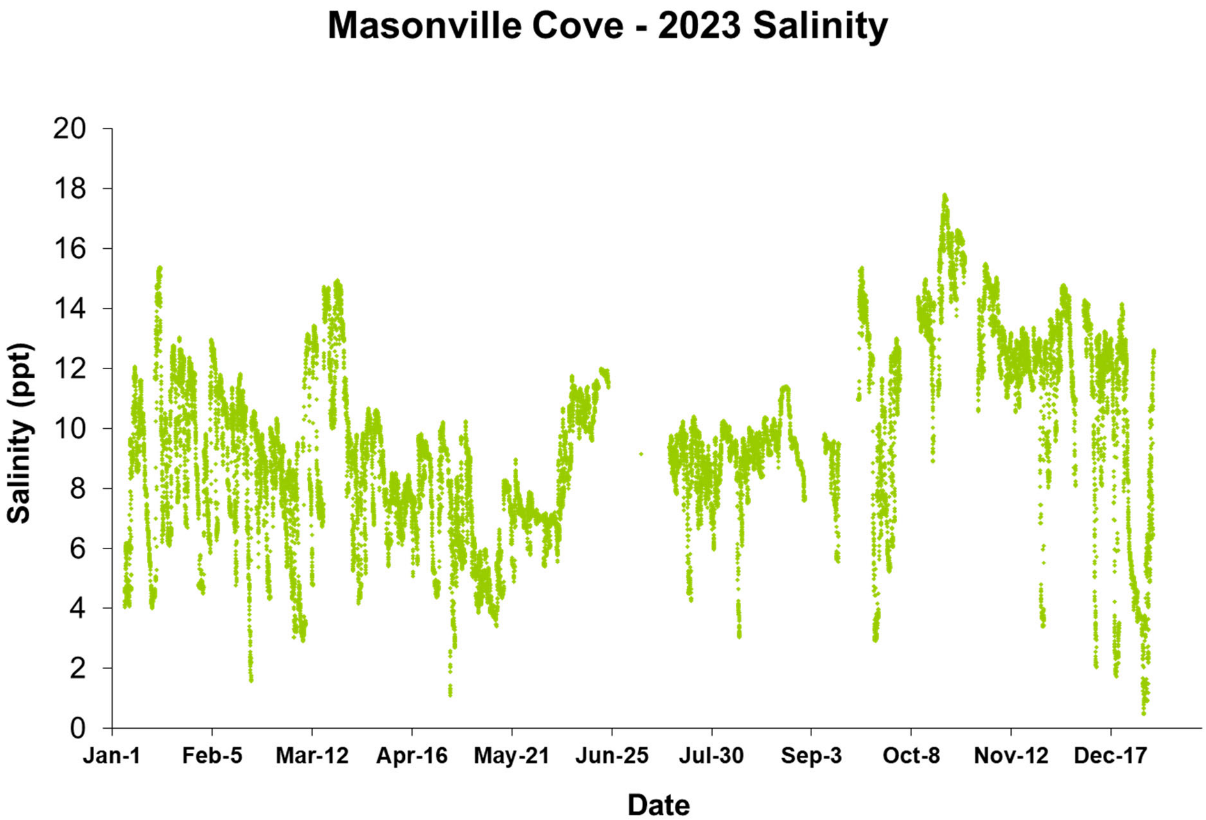

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2023.

Dissolved oxygen

Dissolved oxygen (DO) values remained at healthy levels (< 5 mg/L) through late winter and much of spring (Figure 7). DO concentration peaked to its highest levels (19.2 mg/L; 219% saturation) in 2023 in mid-May. During this same time, DO concentrations also dropped below 5 mg/L for the first time in 2023. These DO measurements coincided with the presence of significant (chlorophyll concentrations greater than 50 µg/L) to severe (concentrations greater than 100 µg/L) algal bloom conditions within Masonville Cove (Figure 8). Large daily swings in DO concentrations, from greater than 10 mg/L during the day to low levels at night, are often observed during algal blooms. Oxygen concentrations can become super-saturated (greater than 100% saturation) and peak during the day when algal cells are photosynthesizing and producing large amounts of oxygen. However, DO concentrations can drop to very low levels at night when photosynthesis ceases, and oxygen is consumed through cellular respiration.

Throughout the year, algal blooms coincided with super-saturated DO concentrations in early January (13.8 mg/L; 119% saturation), late April (15.8 mg/L; 169% saturation), late July and early August (14.6 mg/L; 201% saturation), mid-August (11 mg/L; 146% saturation), mid- to late September (14.5 mg/L; 189% saturation), and late December (15.4 mg/L; 129% saturation). A substantial number of low DO concentrations (< 5 mg/L) was also observed during algal blooms beginning in mid-summer through early fall. 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).

Decreases in DO concentrations can also coincide with the death and decomposition of large algal blooms. The decomposition process can consume significant amounts of oxygen in the water and can lead to conditions harmful to aquatic organisms. Large drops in chlorophyll levels (Figure 8), indicative of the dieback of algal blooms, coincided with large drops in DO concentrations to extremely low levels in late July (0.30 mg/L), and late September and early October (0.36 mg/L). Oxygen readings then increased again in late fall and early winter as water temperature cooled, since cooler waters can hold more dissolved oxygen than warmer waters.

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 in June through September, which is generally the time of year that DO values are the lowest due to warmer waters and higher algal productivity. After four straight years of increasing failure rates, DO failure observations decreased to the lowest rate since 2020 (Table 1). Concentrations were below 5 mg/L 41.5% of the time and below 3.2 mg/L for 20.8% of readings. Even with the decrease in low DO values, both of these failure rates were still higher than the average annual failure rate over the prior fourteen years of monitoring in Masonville Cove (35.4% for 5 mg/L; 16.4% for 3.2 mg/L). Also, when comparing 2023 criteria failure rates to prior years, it should be noted that the 2023 published dissolved oxygen dataset consists of large gaps in the spring and early summer of the growing season due to the censoring of suspect data and equipment problems.

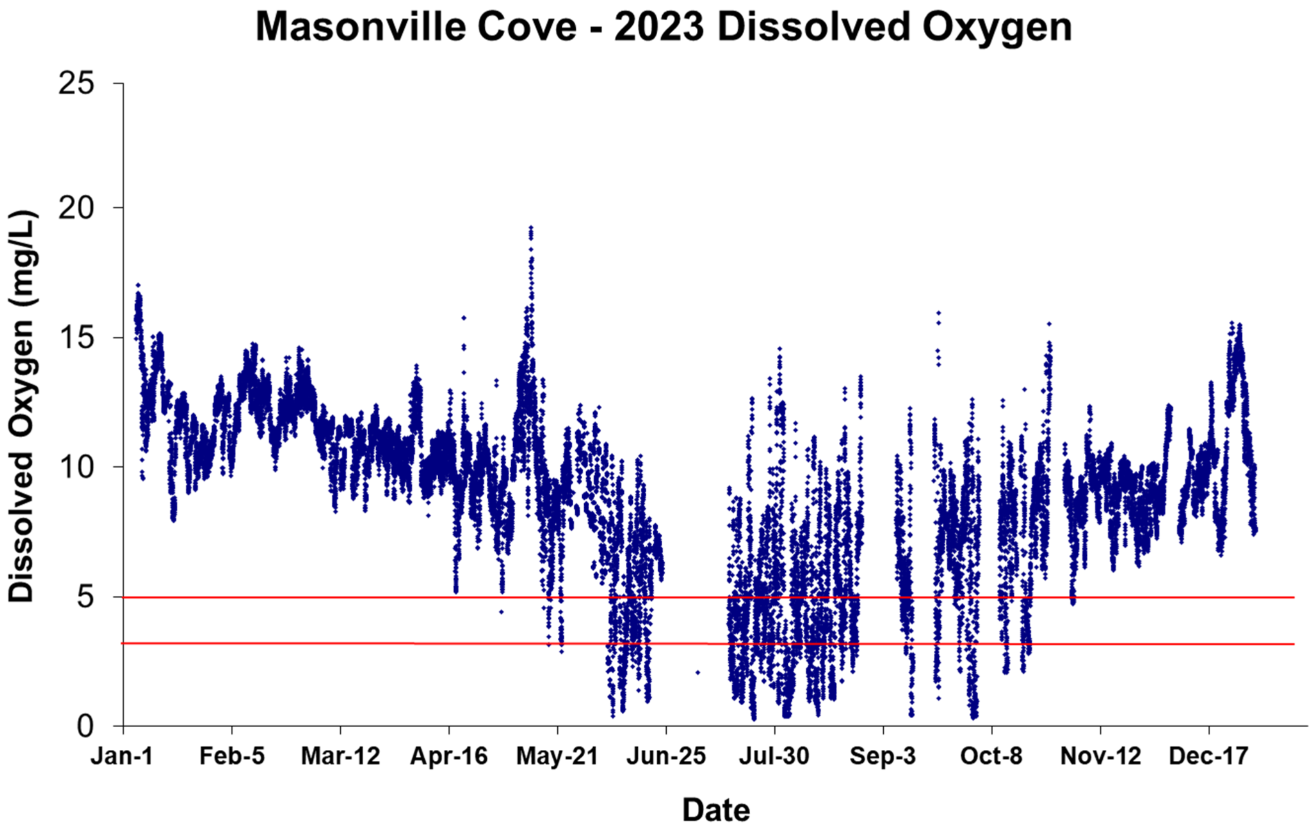

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2023. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove Continuous Monitor from June through September, 2009 to 2023.

DO	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	**2023**
< 5 mg/L	27.2%	36.0%	28.1%	37.0%	37.8%	33.7%	39.2%	48.1%	38.3%	18.2%	23.7%	39.0%	42.2%	47.6%	**41.5%**
< 3.2 mg/L	9.4%	16.4%	10.0%	15.5%	17.2%	12.6%	20.8%	28.5%	19.7%	5.7%	7.7%	20.0%	22.1%	24.6%	**20.8%**

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. At Masonville Cove, measured chlorophyll values indicate that significant or severe algal blooms occurred in eight of the twelve months in 2023 (Figure 8).

Chlorophyll sonde data indicate significant to severe bloom conditions within Masonville Cove starting in early January as concentrations spiked to almost 150 µg/L (Figure 8). Concentrations then dropped and generally remained below 50 µg/L until April. In late April, chlorophyll levels jumped to significant bloom levels and remained at significant to severe levels in May. Most of the chlorophyll data between late May and early July were determined to be suspect in accordance with applied QA/QC protocols and were therefore censored from the published dataset.

When the published dataset resumed in mid-July, chlorophyll concentrations again spiked to significant and severe bloom levels in late July into August, with the highest concentration for the year (449 µg/L) recorded on August 2nd. Chlorophyll levels then dropped to less than 10 µg/L as over two and a half inches of rain fell on the region August 6th-7th, flushing algae from Masonville Cove. Concentrations rebounded to significant bloom levels and sonde data indicate numerous significant algal blooms through September and into October.

Suspect chlorophyll data were censored from the published dataset between mid-November and early December. In late December, severe bloom conditions were observed as chlorophyll concentrations spiked to over 200 µg/L. Over one and half inches of rain fell on the region on December 27th – 28th, which led to an influx of freshwater and corresponding drop in chlorophyll concentrations.

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 2023 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 2023, chlorophyll exceedance rates decreased for the second straight year. Chlorophyll levels exceeded the 15 µg/L threshold during 41.4% of readings and exceeded the 50 µg/L threshold during 2.8% of readings. These rates were also below the long-term (2009 – 2022) average annual rates of 42.9% for 15 µg/L and 5.9% for 50 µg/L. However, when comparing 2023 chlorophyll exceedance rates to prior years, it should be noted that the 2023 published chlorophyll dataset consists of large gaps in the spring and early summer of the growing season due to the censoring of suspect data and equipment problems.

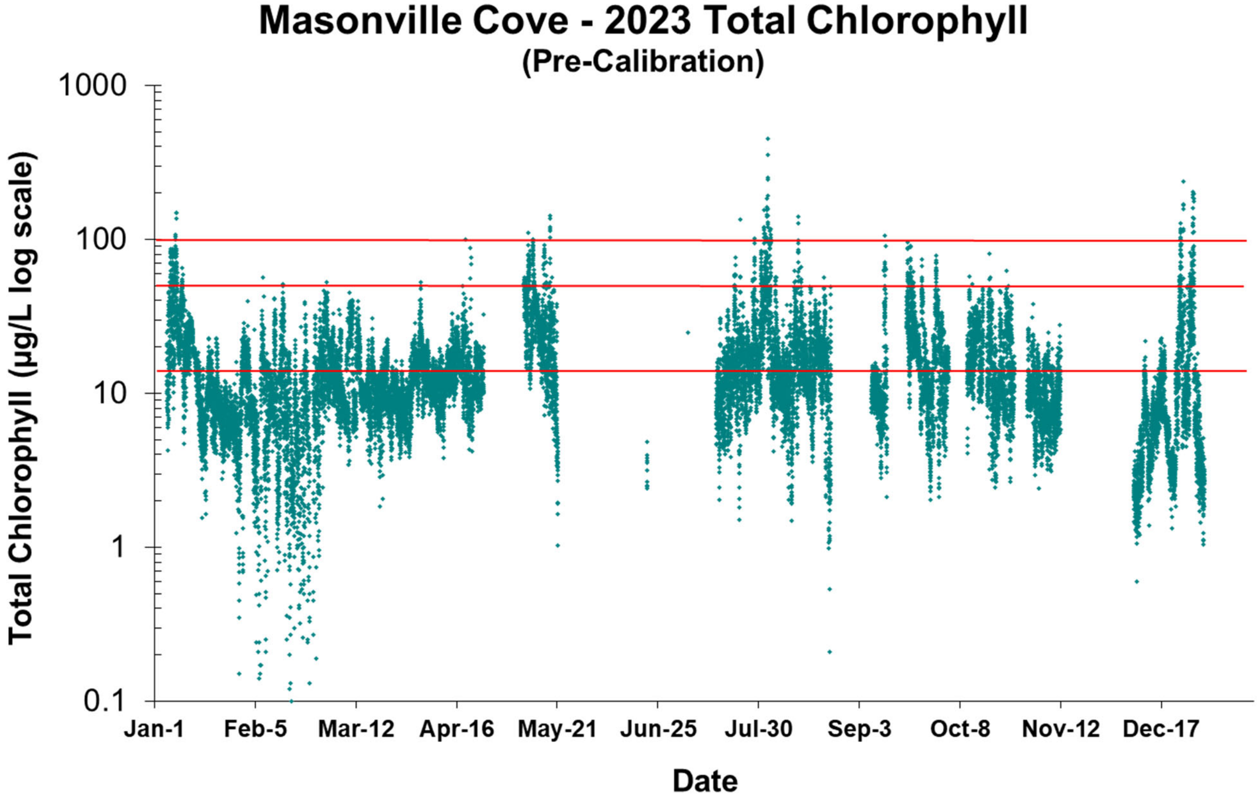

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2023. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 µg/L—are considered significant blooms—50 µg/L—or are considered severe blooms—100 µg/L.)*

Table 2. Chlorophyll threshold failure at Masonville Cove Continuous Monitor during June through November, 2009, March through October, 2010 to 2019 and 2021 to 2023, and the month of March as well as June through October, 2020.

Chla	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020*	2021	2022	**2023**
> 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%	43.2%	51.2%	46.2%	**41.4%**
> 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%	4.5%	10.1%	6.2%	**2.8%**

***Months of data collected limited in 2020 due to COVID-19 pandemic.**

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 in 2023, pH values exceeded 9 during one period of significant to severe algal blooms in mid-May (Figure 9). The highest pH reading of the year (9.4) occurred on May 12th (Figure 8).

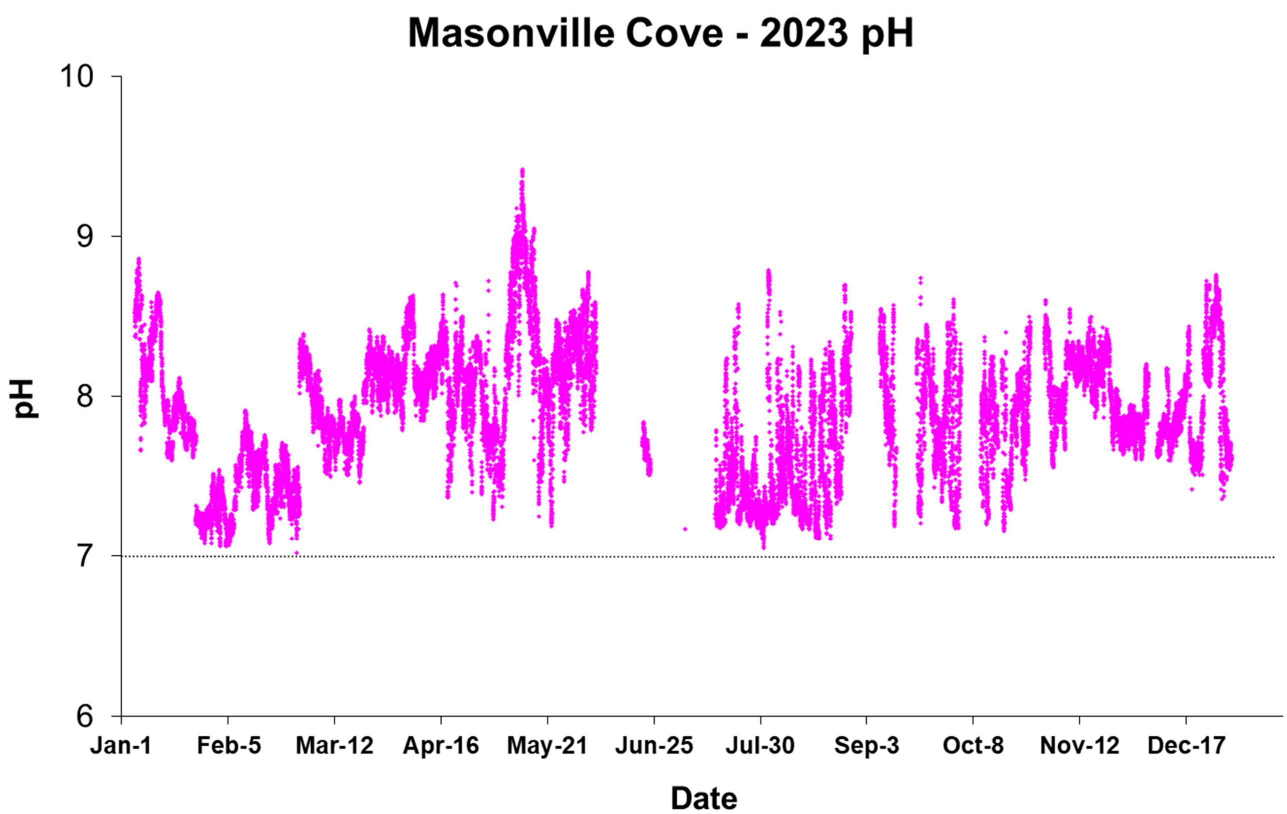

Figure 9. pH levels at Masonville Cove Continuous Monitor during 2023. *(Line indicates neutral pH.)*

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). Heavy rains and associated discharge events can lead to runoff that bring high concentrations of particles and sediment into waterways, leading to increased turbidity levels. Algal blooms can also cloud the water and increase turbidity measurements. During 2023, turbidity readings in Masonville Cove spiked for short periods of time (Figure 10), generally following precipitation events. However, the majority (77%) of turbidity values throughout the year were at or below 7 NTU (mean value: 5.2 NTU; median value: 3.6 NTU).

In January, turbidity measurements started out low and then spiked to over 30 NTU in conjunction with a precipitation event in mid-January. This began a pattern of turbidity values briefly spiking to between 30 and 60 NTU every couple of weeks into late April, usually in conjunction with a rain event. Readings then dropped to less than 5 NTU in April, before briefly spiking again in late April and mid-May. Most of the turbidity data between late May and early July were determined to be suspect in accordance with applied QA/QC protocols and were therefore censored from the published dataset.

When the published dataset resumed in mid-July, turbidity readings were more consistently elevated than they were in spring, perhaps due to the numerous rain events during the wetter than normal month (Figure 3). The highest turbidity reading of the year (132 NTU) occurred on August 14th. This was the only period in 2023 that turbidity measurements were over 100 NTU. Readings generally remained below 30 NTU through September and October and dropped to less than 5 NTU during a dyer than normal November (Figure 3). Turbidity then increased to between 30 NTU and 50 NTU during the middle and end of December as rainfall increased.

Turbidity measurements above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. During the 2023 growing season, the turbidity exceedance rate dropped to the lowest levels since monitoring began in Masonville Cove in 2009. Turbidity readings exceeded the 7 NTU threshold during 30.2% of readings (Table 3). This annual exceedance rate was much lower than the average rate over the prior fourteen years of monitoring (50.2%). However, when comparing 2023 turbidity exceedance rates to prior years, it should be noted that the 2023 published turbidity dataset consists of a large gap in the early summer of the growing season due to the censoring of suspect data and equipment problems.

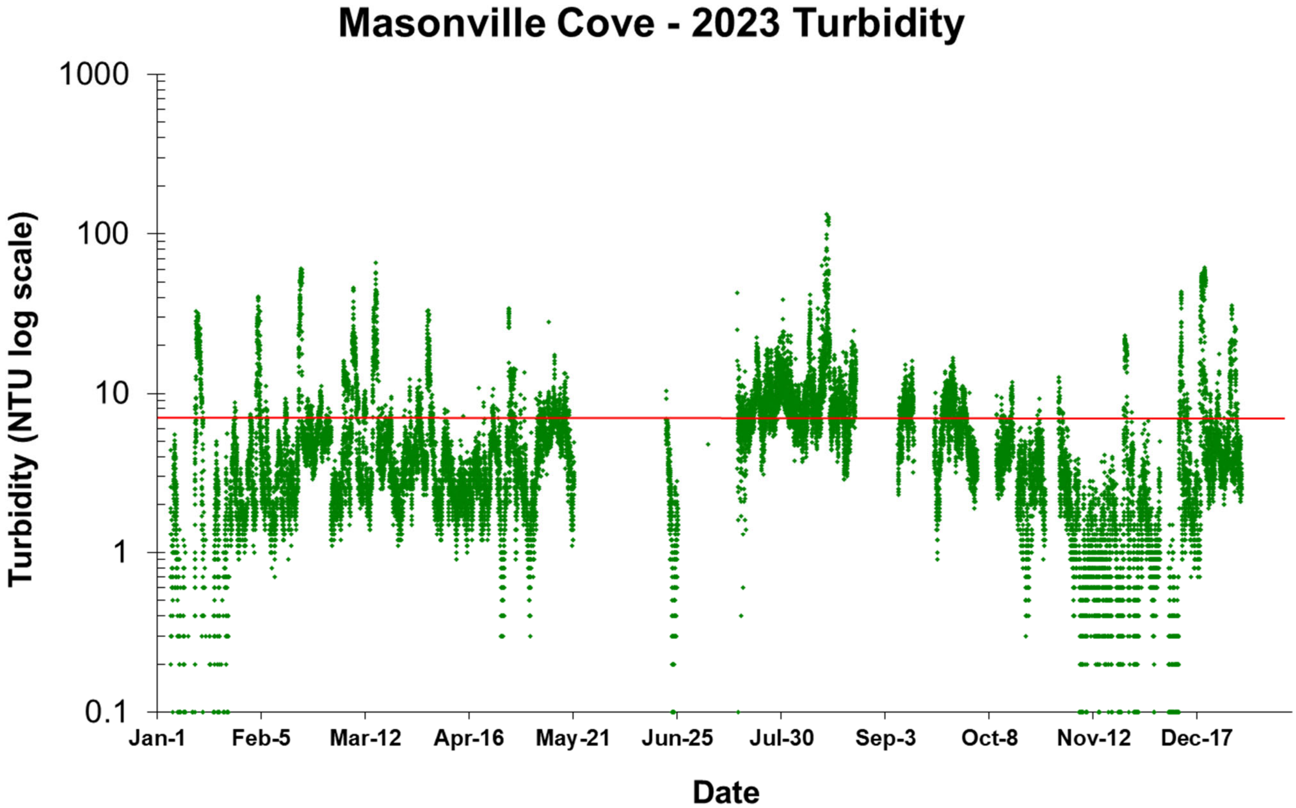

Figure 10. Turbidity levels at Masonville Cove Continuous Monitor during 2023. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failure at Masonville Cove Continuous Monitor during June through December, 2009, March through October, 2010 to 2019 and 2021 to 2023, and the month of March as well as June through October, 2020.

Turb	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020*	2021	2022	**2023**
> 7 NTU	54.6%	60.1%	51.6%	35.0%	53.9%	52.9%	53.8%	34.9%	60.9%	53.8%	56.9%	34.3%	49.5%	50.1%	**30.2%**

***Months of data collected limited in 2020 due to COVID-19 pandemic.**

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 the total area and density of SAV within the Patapsco beginning in 1994 (the first year SAV was found in the river) through 2023.

The total area of SAV within the Patapsco River in 2023 was almost 180 acres, all of which was located in tributaries of the river while 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, total acreage observed in 2023 increased for the seventh straight year and was the most coverage found in the segment since the mid-2000s when a population explosion and range expansion of dark false mussels (*Mytilopsis leucophaeata*) increased water clarity and allowed SAV coverage to significantly expand (L. Karrh, MD DNR, personal communication). In 2023, the total area of SAV within the Patapsco River system increased 1.7% from the prior year, and over 5,000% since 2016 when only 3.5 acres were found. The total area of SAV within the Patapsco River system currently stands at 46% of the total restoration goal of 389 acres.

The increase in SAV coverage seen in the Patapsco River system since 2016 is similar to the recent trends found throughout the Chesapeake Bay watershed. Bay-wide SAV coverage declined 40% between 2017 and 2020 but have increased by over 25% in the last three years. Approximately 79,000 acres were observed bay-wide in 2023, which is 43% of the restoration goal of almost 185,000 acres. Further information about the status of SAV within the Chesapeake Bay watershed can be found at: https://www.vims.edu/research/units/programs/sav/reports/2023/.

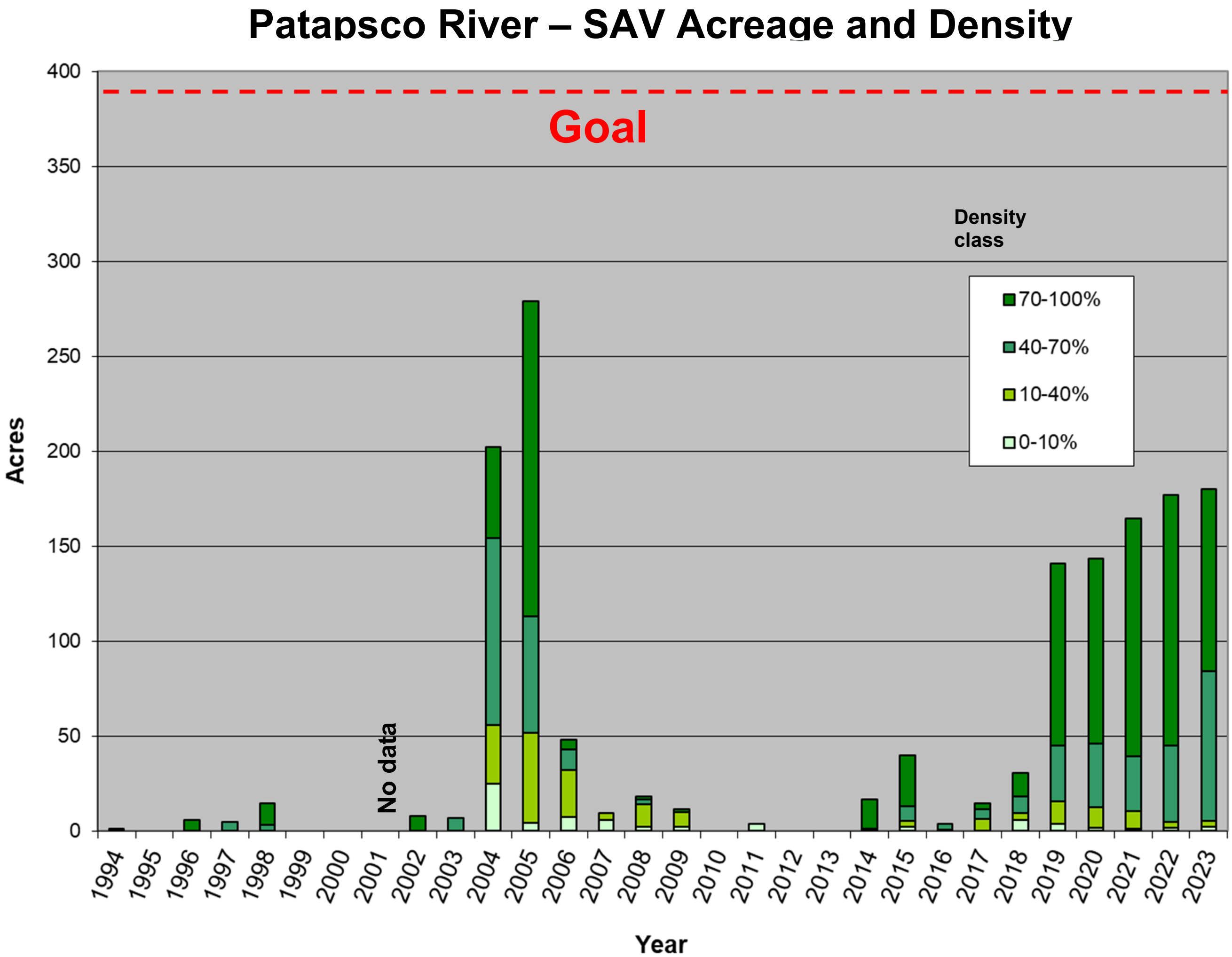

Figure 11. Total area and density of SAV in the Patapsco River between 1994 and 2023. (*Restoration goal is 389 acres)*

Pigments, Suspended Solids and Secchi Depths

Bi-weekly or monthly grab samples of water were taken at the Masonville Cove station when the YSI meters were exchanged during continuous monitoring service visits. Secchi depth, a measure of water clarity, was also recorded at the Masonville Cove station each time a grab sample was collected. In total, 18 samples were collected in 2023 (Table 4).

Samples collected during continuous monitoring service visits were analyzed for pigments and suspended solids. The water samples were processed in the field using vacuum filtration, and the resulting particulate samples were delivered to the laboratory for analysis. 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: https://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/SWM_QAPP_July2023.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 values are also documented in Table A-1 of Appendix A.

Table 4. Deployment and calibration record for Masonville Cove continuous monitor in 2023.

Station service date	Samples collected	Comment
January 5th, 2023	No	Telemetry data reestablished following a malfunction beginning on December 25th
January 25th, 2023	Yes	Routine maintenance performed on deployment equipment
February 28th, 2023	Yes	
March 21st, 2023	Yes	
April 11th, 2023	Yes	
April 25th, 2023	Yes	
May 9th, 2023	Yes	Service visits suspended following enforced no entry policy due to eagle nesting site
June 21st, 2023	Yes	Regular service visits resumed
July 5th, 2023	Yes	Attempted repair of malfunctioning telemetry unit unsuccessful
July 18th, 2023	Yes	Telemetry data reestablished following a malfunction beginning on June 20th
August 1st, 2023	Yes	
August 2nd, 2023	No	Telemetry unit solar panel replaced
August 15th, 2023	Yes	
August 22nd, 2023	Yes	
September 7th, 2023	Yes	
September 19th, 2023	Yes	Telemetry data reestablished following a malfunction beginning on September 12th
October 3rd, 2023	Yes	Profile of water quality measurements not collected due to power failure of discrete water quality meter
October 17th, 2023	Yes	
October 31st, 2023	No	Attempted repair of malfunctioning telemetry unit unsuccessful
November 7th, 2023	Yes	Replacement telemetry unit deployed
December 7th, 2023	Yes	Telemetry data reestablished following a malfunction beginning on December 4th

Pigments

Chlorophyll concentrations at Masonville Cove started off 2023 below 30 µg/L through April (Figure A-1). Concentrations then increased to significant bloom conditions in early May (55 µg/L) and early July (69 µg/L). Starting in mid-July, concentrations generally displayed a declining pattern through the remainder of the year as precipitation doubled over the second half of 2023 as compared to the first half (Figure 3).

Pheophytin values in 2023 showed a general pattern of lower values in the winter and spring, with more elevated concentrations in the summer and fall, which is consistent with the pattern seen in previous years (Figure A-2). Pheophytin concentrations in January through May and mid-October through December were all less than 5 µg/L. Pheophytin concentrations between June and late August fluctuated between approximately 5 µg/L and 10 µg/L. From early September through early October, pheophytin concentrations fluctuated between approximately 4 µg/L and 16 µg/L.

Suspended solids

In 2023, suspended solids concentrations at Masonville Cove ranged between 7 mg/L and 34 mg/L (Figure A-3). Concentrations were generally less than 20 mg/L except for two peaks to 34 mg/L in mid-April and 32 mg/L in late August. Suspended solid concentrations are not available for November and December because results were rejected due to quality control criteria.

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. The lowest Secchi depth value at Masonville Cove in 2023 (0.3 m) was recorded on August 15th, a date when higher values of total suspended solids and chlorophyll were observed (Figure A-4). The highest Secchi depth in 2023 (1.8 m) occurred on December 7th. Suspended solids concentrations are not available for this date.

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 0.5 meter depth intervals through the water column. 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

The measured daily mean salinity at Masonville Cove in 2023 averaged 10 ppt for the year (Figure A-5). The highest salinities were observed in late March (13.8 ppt), mid-October (12.8 ppt), early November (13.7 ppt), and early December (13.6 ppt). These all occurred during times of reduced precipitation (Figure 3). The lowest daily mean salinity concentrations occurred in mid-April (6.9 ppt) and early May (5.1 ppt). Some stratification of the water column was evident in the salinity readings for late April and mid-October as surface and bottom water salinities differed by more than 4 ppt during these times.

Dissolved oxygen

Dissolved oxygen concentrations greater than 5mg/L are considered necessary to support a healthy marine ecosystem. Daily mean values of dissolved oxygen at Masonville Cove were observed below this threshold beginning in early July through mid-August (Figure A-6). On July 5th, the surface waters (0.5 – 1m depth) were near hypoxic (< 2 mg/L), while the bottom waters (1.5 – 2m depth) had DO concentrations less than 1 mg/L. These readings occurred on the same date as measured chlorophyll concentrations indicated a significant algal bloom (Figure A-1). DO concentrations on July 18th were also less than 5 mg/L throughout the entire water column and hypoxic at the bottom. Surface water DO concentrations were above 5 mg/L during the two August dates (August 1st and 15th) that had daily mean DO concentrations less than 5 mg/L. DO concentrations less than 5 mg/L were also recorded in bottom waters in early September and mid-October. The highest DO concentrations (> 11 mg/L) of 2023 were recorded January through March and in early May.

Water temperature and pH

Water temperatures varied seasonally at Masonville Cove in 2023 (Figure A-7). Water temperatures ranging from 5.3 °C to 9.2 °C were measured from January through March. As the weather warmed, water temperatures gradually rose to a peak value of 28 °C on July 18th and remained at or near those levels into September. As the air cooled, temperatures declined steadily to 10 °C in early December.

The pattern of pH values (Figure A-8) at Masonville Cove in 2023 closely matched the pattern of dissolved oxygen concentrations. Daily mean pH values ranged between 7.1 and 8.2 during the year. An increase in pH values is often observed with algal blooms, and this was evident during severe algal bloom conditions in early May as pH values peaked for the year (8.2) on May 9th during this bloom event.

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2023. 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 2023, algal and dissolved oxygen conditions were improved as compared to prior years and water clarity conditions were the best since monitoring began in Masonville Cove in 2009. However, it may be problematic to compare 2023 results to prior years since suspect data and equipment problems led to large data gaps during the warmer, wetter months of 2023, which could have skewed results. Furthermore, submerged aquatic vegetation continue to not be found within Masonville Cove and habitat conditions remain poor for living resources.

Shallow water monitoring information is not only used for characterizing the health of shallow water habitats, but it is also useful for: 1) assessing the 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)

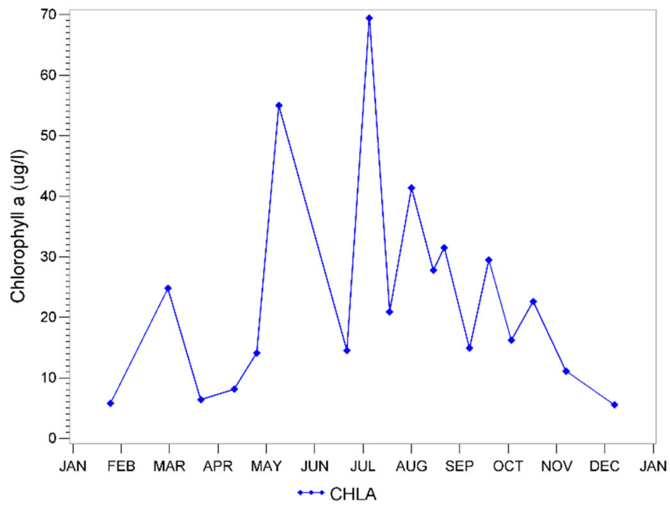

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2023.

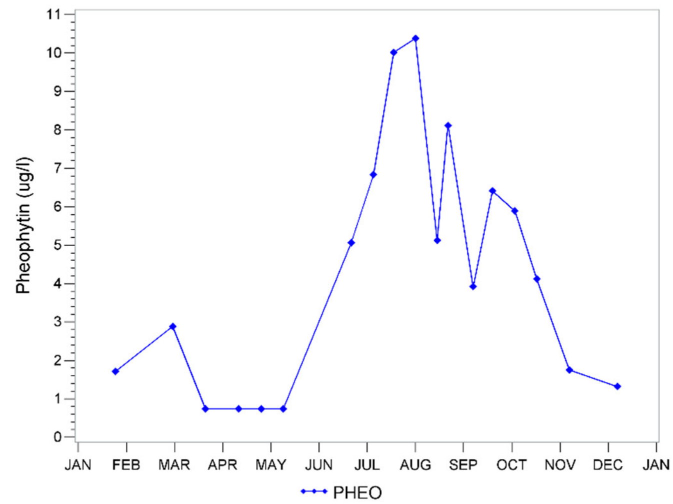

Figure A-2. Pheophytin concentrations at Masonville Cove in 2023.

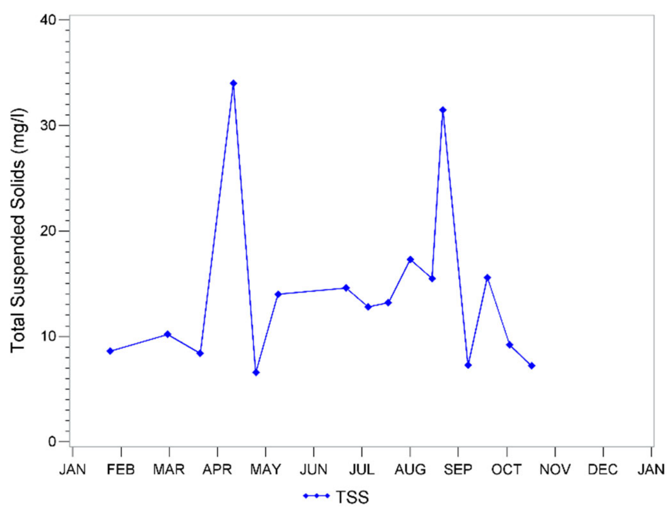

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2023.

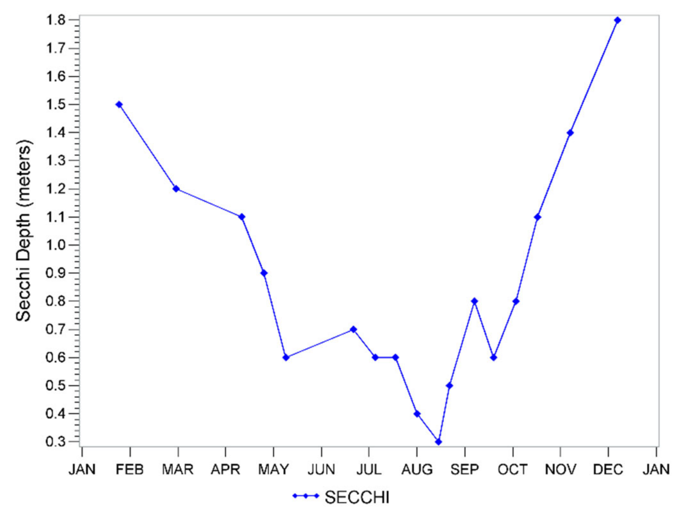

Figure A-4. Secchi depth at Masonville Cove in 2023.

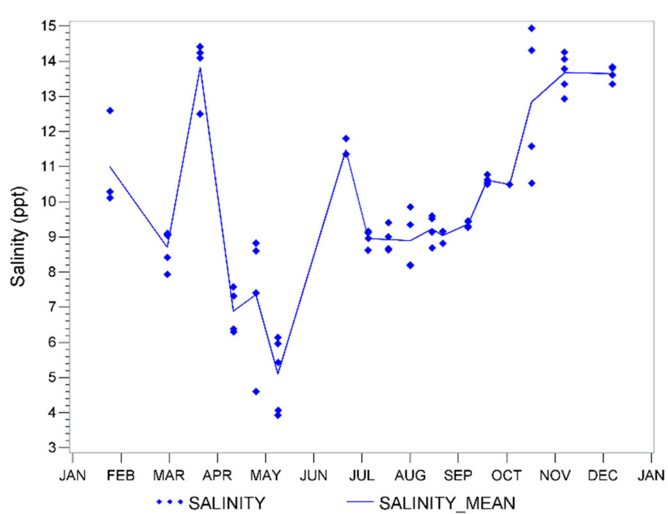

Figure A-5. Salinity concentrations at Masonville Cove in 2023.

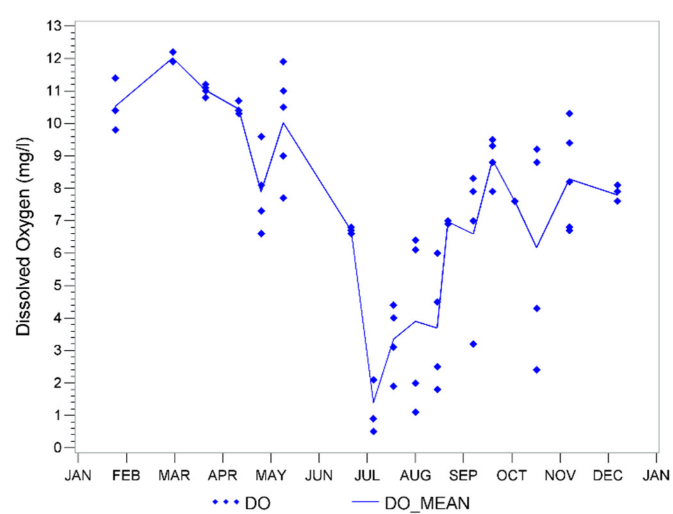

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2023.

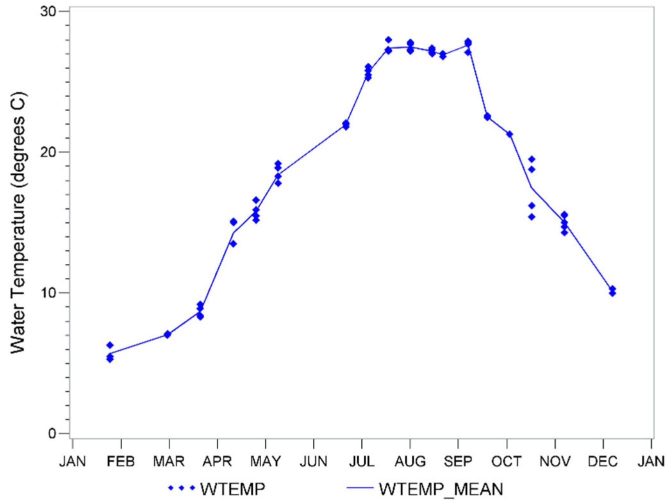

Figure A-7. Water temperature at Masonville Cove in 2023.

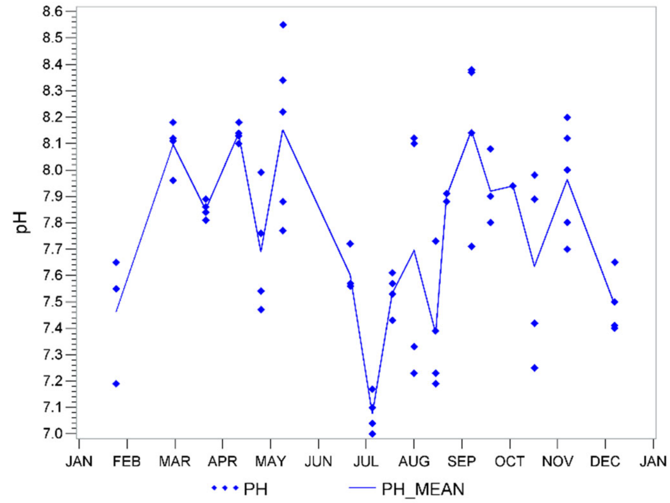

Figure A-8. Values of pH at Masonville Cove in 2023.

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 2023.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Pheophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
1/25/2023	1	5.767	1.709	8.6	1.5
2/28/2023	1	24.778	2.884	10.2	1.2
3/21/2023	1	6.408	< 0.74	8.4	no data[3]
4/11/2023	1	8.117	< 0.74	34	1.1
4/25/2023	1	14.098	< 0.74	6.6	0.9
5/9/2023	1	55.002	< 0.74	14	0.6
6/21/2023	1	14.525	5.062	14.6	0.7
7/5/2023	1	69.42	6.835	12.8	0.6
7/18/2023	1	20.933	10.018	13.2	0.6
8/1/2023	1	41.385	10.386	17.3	0.4
8/15/2023	1	27.768	5.126	15.5[1]	0.3
8/22/2023	1	31.506	8.117	31.5[1]	0.5
9/7/2023	1	14.952	3.925	7.3	0.8
9/19/2023	1	29.477	6.408	15.6	0.6
10/3/2023	1	16.234	5.895	9.2[1]	0.8
10/17/2023	1	22.642	4.122	7.2	1.1
11/7/2023	1	11.107	1.752	no data[2]	1.4
12/7/2023	1	5.554	1.324	no data[2]	1.8

1) Poor replication between pads, mean reported.

2) Sample results rejected due to quality control criteria.

3) No Secchi depth taken.

Table A-2. Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2023 (continued on next page).

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
1/25/2023	0.5	10.4	7.65	10.28	5.5
1/25/2023	1	11.4	7.19	10.11	5.3
1/25/2023	1.7	9.8	7.55	12.59	6.3
2/28/2023	0.5	12.2	8.18	7.94	7.1
2/28/2023	1	12.2	7.96	8.42	7.1
2/28/2023	1.5	11.9	8.11	9.04	7
2/28/2023	2	11.9	8.11	9.07	7
2/28/2023	2.3	11.9	8.12	9.1	7
3/21/2023	0.5	11	7.81	12.5	9.2
3/21/2023	1	10.8	7.89	14.09	8.9
3/21/2023	1.5	11.2	7.86	14.24	8.4
3/21/2023	1.8	11.1	7.84	14.41	8.3
4/11/2023	0.5	10.4	8.1	6.38	15.1
4/11/2023	1	10.3	8.13	6.3	15
4/11/2023	1.5	10.7	8.18	7.32	13.5
4/11/2023	2.1	10.4	8.14	7.58	13.5
4/25/2023	0.5	9.6	7.99	4.61	15.2
4/25/2023	1	8.1	7.76	7.4	16.6
4/25/2023	1.5	6.6	7.47	8.61	15.9
4/25/2023	2.2	7.3	7.54	8.82	15.5
5/9/2023	0.5	11.9	8.55	3.93	19.2
5/9/2023	1	11	8.34	4.07	18.9
5/9/2023	1.5	10.5	8.22	5.43	18.3
5/9/2023	2	9	7.88	5.96	17.8
5/9/2023	2.5	7.7	7.77	6.14	17.8
6/21/2023	0.5	6.7	7.57	11.36	22.1
6/21/2023	1	6.8	7.72	11.8	21.8
6/21/2023	1.5	6.7	7.56	11.36	22.1
6/21/2023	2.2	6.6	7.56	11.36	22
7/5/2023	0.5	2.1	7.1	8.62	26.1
7/5/2023	1	2.1	7.17	8.96	25.8
7/5/2023	1.5	0.9	7.04	9.12	25.5
7/5/2023	2	0.5	7	9.16	25.3
7/18/2023	0.5	4	7.61	8.67	27.3
7/18/2023	1	4.4	7.57	8.63	27.2
7/18/2023	1.5	3.1	7.53	9	27.2
7/18/2023	2	1.9	7.43	9.41	28

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2023.

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
8/1/2023	0.5	6.4	8.1	8.2	27.3
8/1/2023	1	6.1	8.12	8.18	27.2
8/1/2023	1.5	2	7.33	9.35	27.8
8/1/2023	2.2	1.1	7.23	9.85	27.7
8/15/2023	0.5	6	7.73	8.69	27.4
8/15/2023	1	4.5	7.39	9.14	27.3
8/15/2023	1.5	2.5	7.23	9.52	27.1
8/15/2023	1.8	1.8	7.19	9.6	27
8/22/2023	0.5	7	7.91	9.16	27
8/22/2023	1	6.9	7.88	8.82	26.8
8/22/2023	1.5	7	7.91	9.15	27
9/7/2023	0.5	7.9	8.37	9.27	27.9
9/7/2023	1	8.3	8.38	9.46	27.8
9/7/2023	1.5	7	8.14	9.3	27.7
9/7/2023	1.9	3.2	7.71	9.43	27.1
9/19/2023	0.5	9.3	7.9	10.5	22.5
9/19/2023	1	9.5	8.08	10.77	22.5
9/19/2023	1.5	8.8	7.9	10.56	22.5
9/19/2023	1.8	7.9	7.8	10.63	22.6
10/3/2023	1	7.6	7.94	10.5	21.3
10/17/2023	0.5	9.2	7.98	10.53	15.4
10/17/2023	1	8.8	7.89	11.58	16.2
10/17/2023	1.5	4.3	7.42	14.31	18.8
10/17/2023	2	2.4	7.25	14.94	19.5
11/7/2023	0.5	10.3	8.2	12.93	14.3
11/7/2023	1	9.4	8.12	13.35	14.7
11/7/2023	1.5	8.2	8	13.79	15
11/7/2023	2	6.8	7.7	14.26	15.6
11/7/2023	2.3	6.7	7.8	14.06	15.5
12/7/2023	0.5	8.1	7.5	13.35	10
12/7/2023	1	7.9	7.65	13.61	10
12/7/2023	1.5	7.6	7.4	13.81	10.3
12/7/2023	1.9	7.6	7.41	13.84	10.3