MARYLAND DEPARTMENT OF NATURAL RESOURCES

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2022 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive summary

Masonville Cove, a small inlet of the upper tidal Patapsco River, figures in local Baltimore lore as a natural respite from the rigors of early 20th-century city life. However, as the Patapsco River was heavily impacted by pollution from centuries of being a center of commerce and population, so too was Masonville Cove. In 2007, the Maryland Port Administration received a permit to build a dredged material containment facility at the Masonville Marine Terminal, adjacent to Masonville Cove. As part of the mitigation agreement for this project, the Maryland Department of Natural Resources (DNR) deployed a continuous water quality monitor in the summer of 2009, ahead of the construction of the dredged material containment facility. Since 2009, DNR has continued to deploy a monitor during most of the year, although it has been removed in the winter in some years due to icing conditions. In continuation of this project, a water quality monitor was deployed off the Masonville Cove pier during the entirety of 2022.

Results from 2022 indicate continuing poor habitat conditions in Masonville Cove. Dissolved oxygen concentrations degraded for the fourth straight year and were among the worst conditions observed since monitoring began in Masonville Cove. These results coincided with high algal concentrations and frequent blooms. Lastly, water clarity conditions within Masonville Cove were similar to those of prior monitoring years. Together, these 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 2022 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 2022 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://data.chesapeakebay.net/api.CSV/WaterQuality/WaterQuality/3-27-2013/12-31-2022/0/4/2/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://data.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 2022, 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 2022. 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 2022, 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.

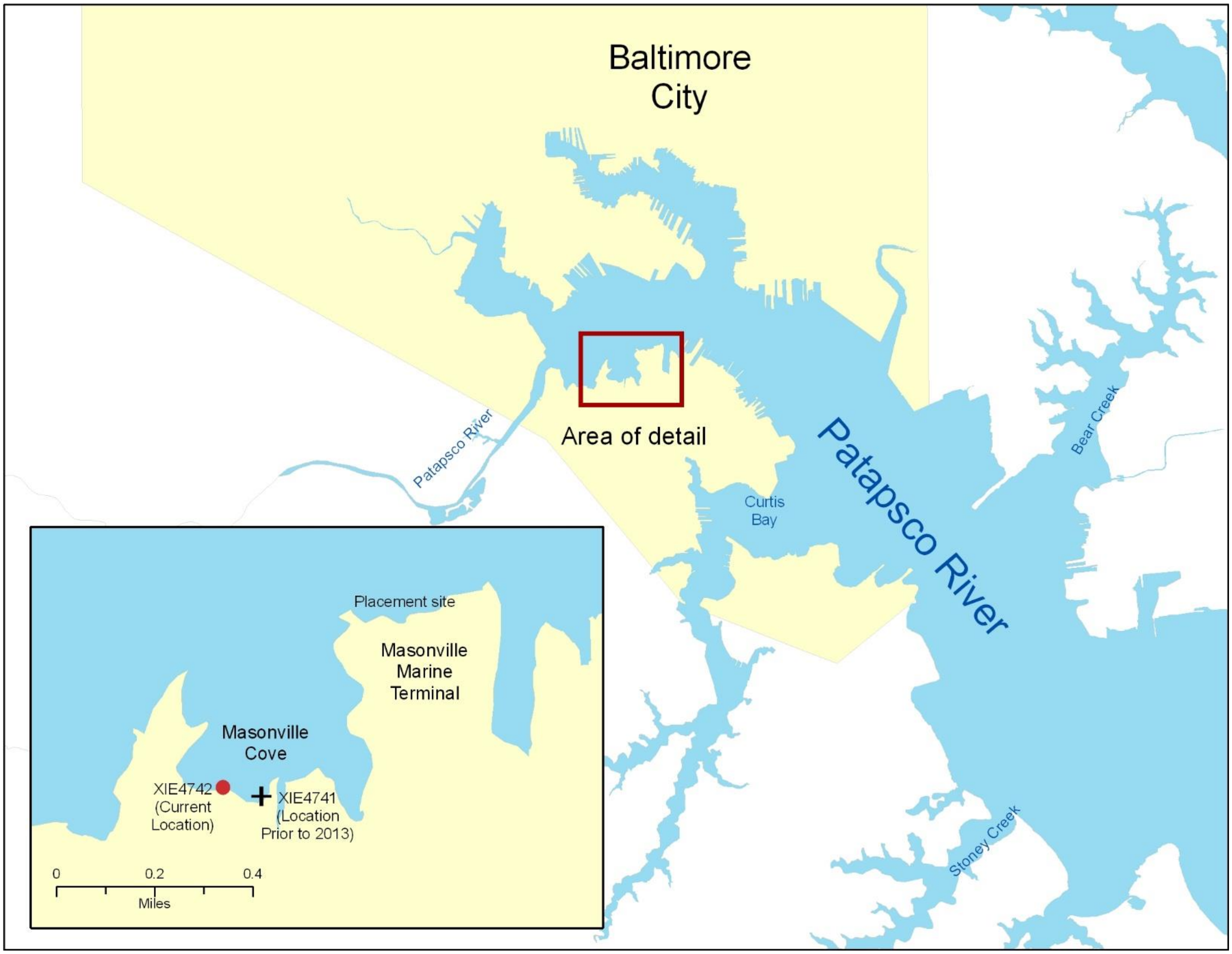

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2022 continuous monitor location within the cove, the location of the monitor prior to 2013, and the approximate site for dredged material placement.

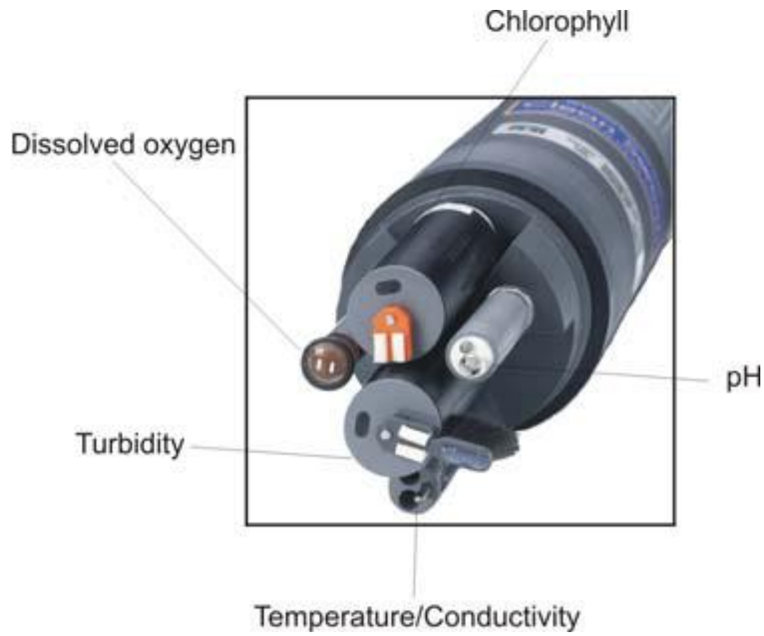

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

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 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 2022, a continuous monitor at Masonville Cove was deployed for the entire year. Data sondes collected 30,012 data records and 20 calibration samples were collected and analyzed in 2022. Calibration samples were collected when sondes were changed out every two weeks between April and October and every four weeks between November and March.

A malfunction to the deployed water quality monitoring sonde precluded data collection between February 20th and April 7th and between December 25th and December 31st. Additional gaps in the data are where questionable data were removed for quality assurance purposes. Automated telemetry generally operated when deployed, but there were times when telemetry did not work properly, which led to gaps in near real-time web presentation of the data. Telemetry issues did not, however, impede the sonde from collecting data.

2022 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 2022 at Baltimore Washington International (BWI) Thurgood Marshall Airport was roughly equivalent to the long-term norm (Figure 3). Total precipitation was 47.18 inches, which is 2.18 inches above the 30-year average. Total precipitation was above monthly averages in six of the twelve months. July was the wettest month of the year at 6.25 inches of rain (Figure 3), with most of that falling between July

5th and July 9th. May was the second wettest month of 2022 at 5.39 inches, while February was the driest month of the year at 2.31 inches.

Daily mean discharge at the United States Geological Survey (USGS) gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2022 (Figure 4). Gage data show numerous spikes throughout 2022, which are indicative of the precipitation events that affected the region during the year. The largest flows of the year occurred on May 7th and December 23rd in association with heavy rains those days. These flow events were more than 500 cubic feet per second (cfs) greater than the daily medians measured over 57 years, reflecting very high discharge levels into the Patapsco River and the Chesapeake Bay. Extremely high flows more than 300 cfs greater than the daily median were also measured following heavy rains on May 6th, September 6th, October 4th, and December 15th-16th.

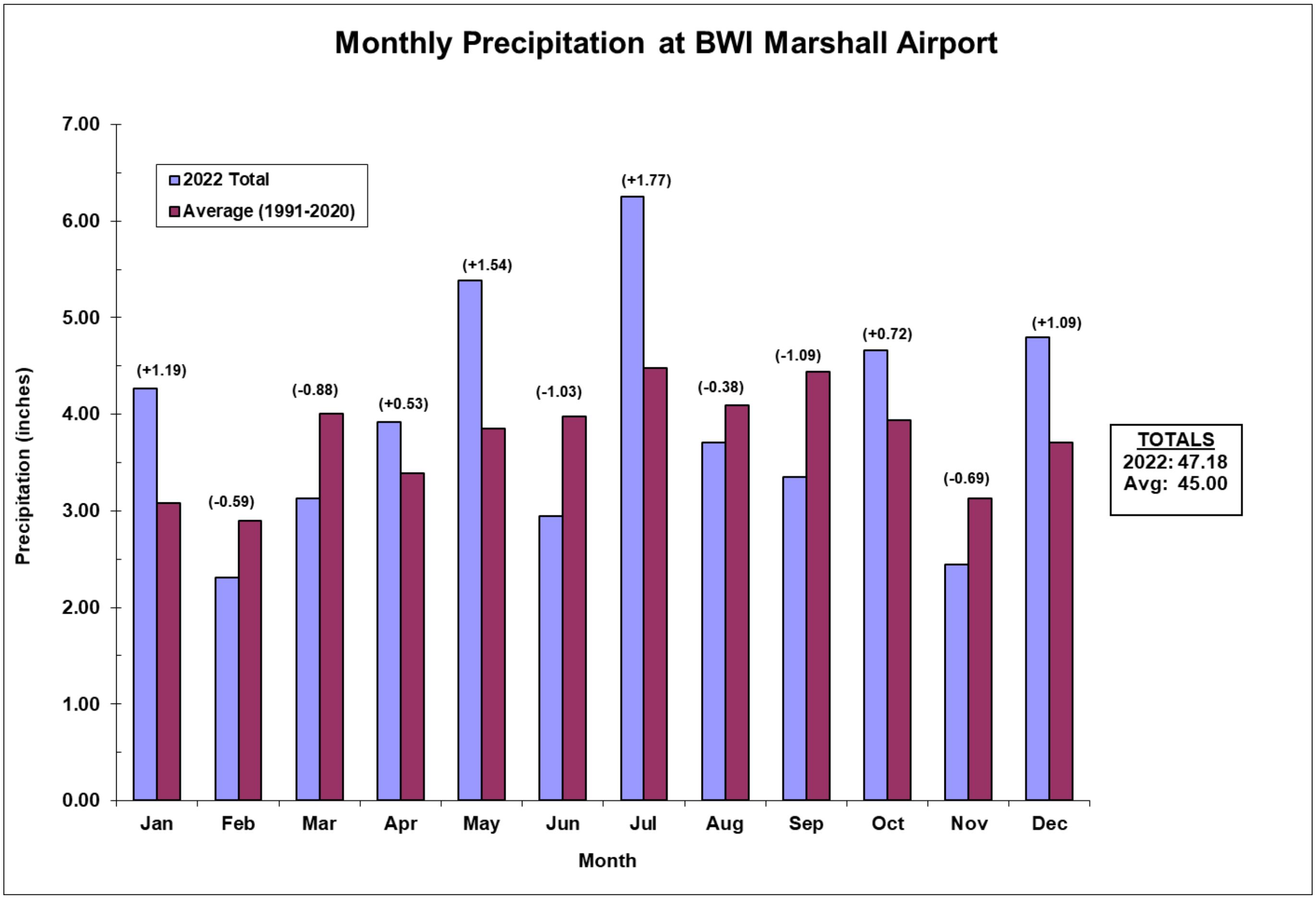

Figure 3. Total 2022 monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages. Data source: National Weather Service (weather.gov/media/lwx/climate/bwiprecip.pdf).

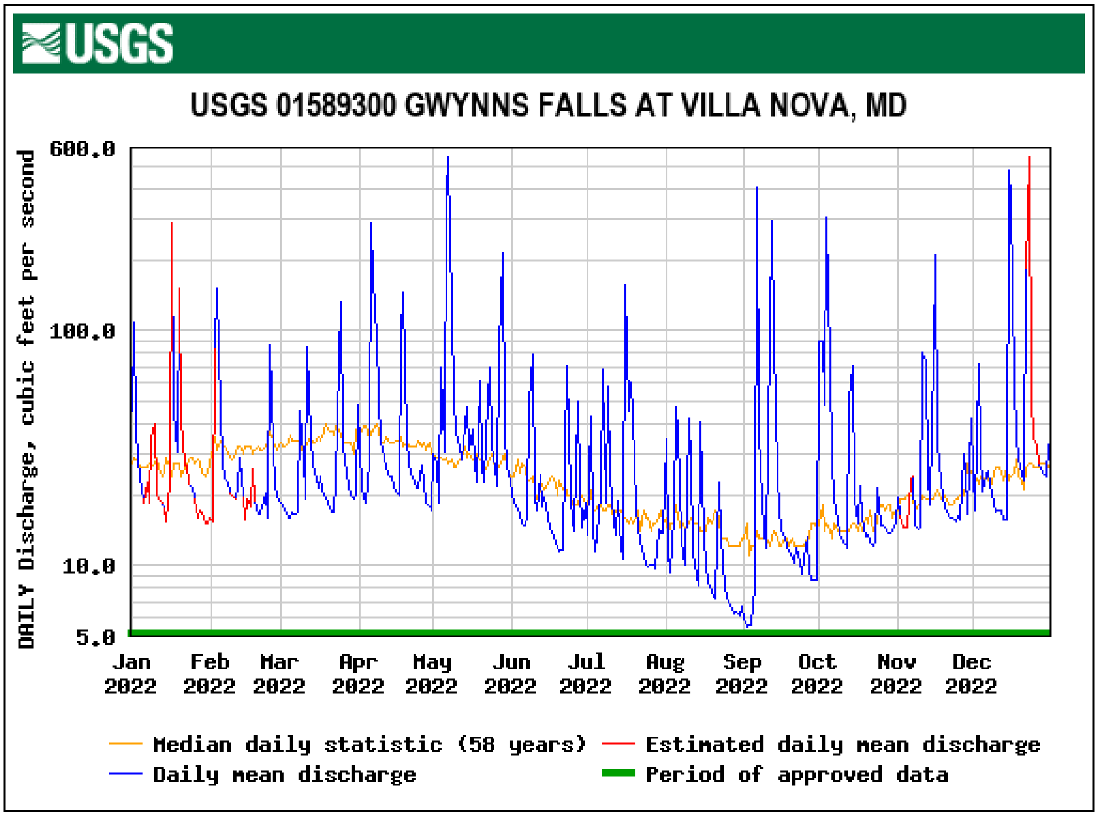

Figure 4. 2022 daily discharge in cubic feet per second measured at a USGS gaging station northwest of Masonville Cove. Graph courtesy of the United States Geological Survey (https://waterdata.usgs.gov/nwis/dv/?site_no=01589300).

2022 Continuous Monitoring Data

Water temperature

Water temperatures at Masonville Cove declined during the first few weeks of 2022 to near freezing levels. Temperatures then rose predictably during the next several months as air temperatures increased (Figure 5). Water temperatures peaked at 32°C (~90º F) in mid-August and generally remained between 25-30°C (77-86º F) into mid- to late September. Heavy rains during the first week of October led to an approximately 10°C (15º F) drop, which precipitated a decline in water temperatures, as air temperatures cooled, through the rest of the year. Variability in the plot in Figure 5 was most likely a result of diel variation in temperature (warming temperatures during the day and cooling temperatures during the night).

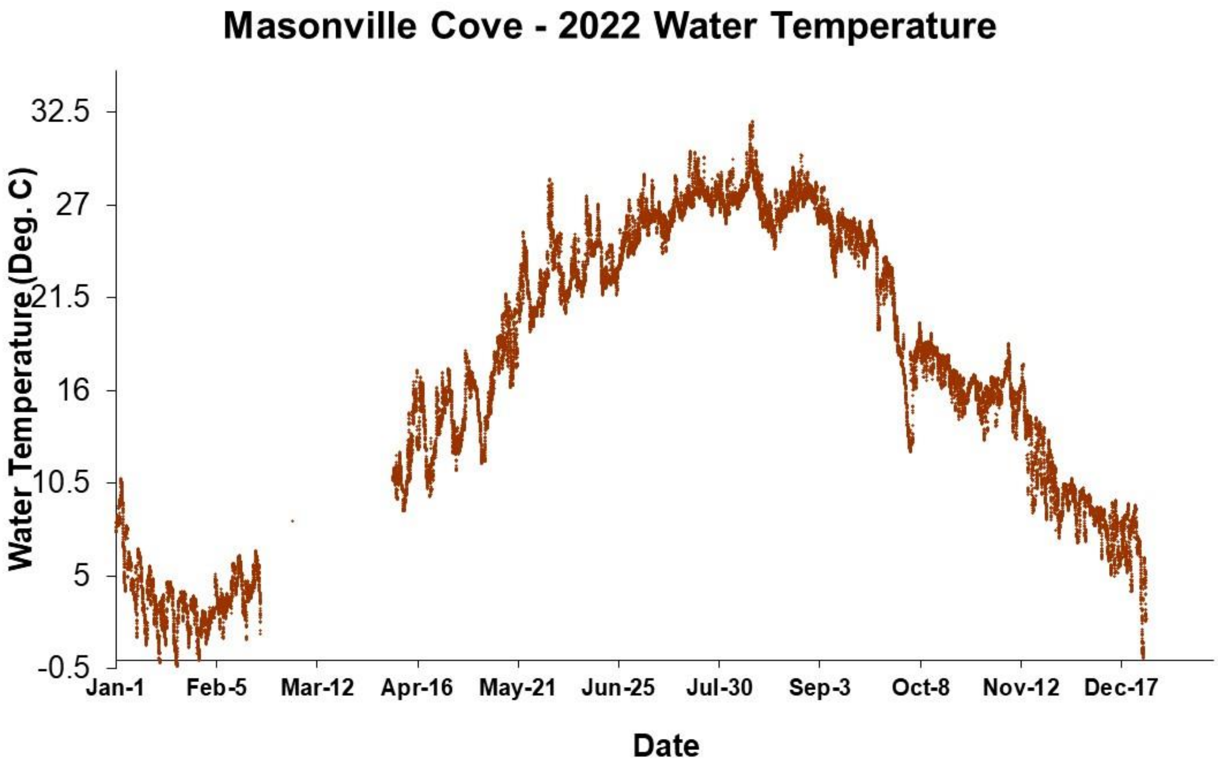

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2022.

Salinity

Salinity tends to vary with precipitation and streamflow. The general annual trend in salinity that has been observed at Masonville Cove since monitoring began in 2009 is higher values in late winter and early spring, a drop in readings during the wetter summer months, and a rise in values again in the late fall and early winter. The overall pattern in 2022 (Figure 6) deviated from this during a wetter than normal January (Figure 3) and early February with salinities fluctuating between 2 and 10 parts per thousand (ppt) in conjunction with numerous precipitation events. Salinity concentrations remained depressed during wetter than normal April and May. The lowest concentration of 2022 (0.47 ppt) was recorded on May 9th, following over two inches of rain that fell on the region. Concentrations then rose into early October before dropping to near 2 ppt following heavy rains. Although salinity dropped briefly following rain events, concentrations generally ranged between 9 and 14 ppt for much of the rest of the year, with the highest reading of 2022 (16.9 ppt) recorded on December 21st.

Salinity readings in Masonville Cove often quickly dropped to near 0 ppt following a rain event, 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.

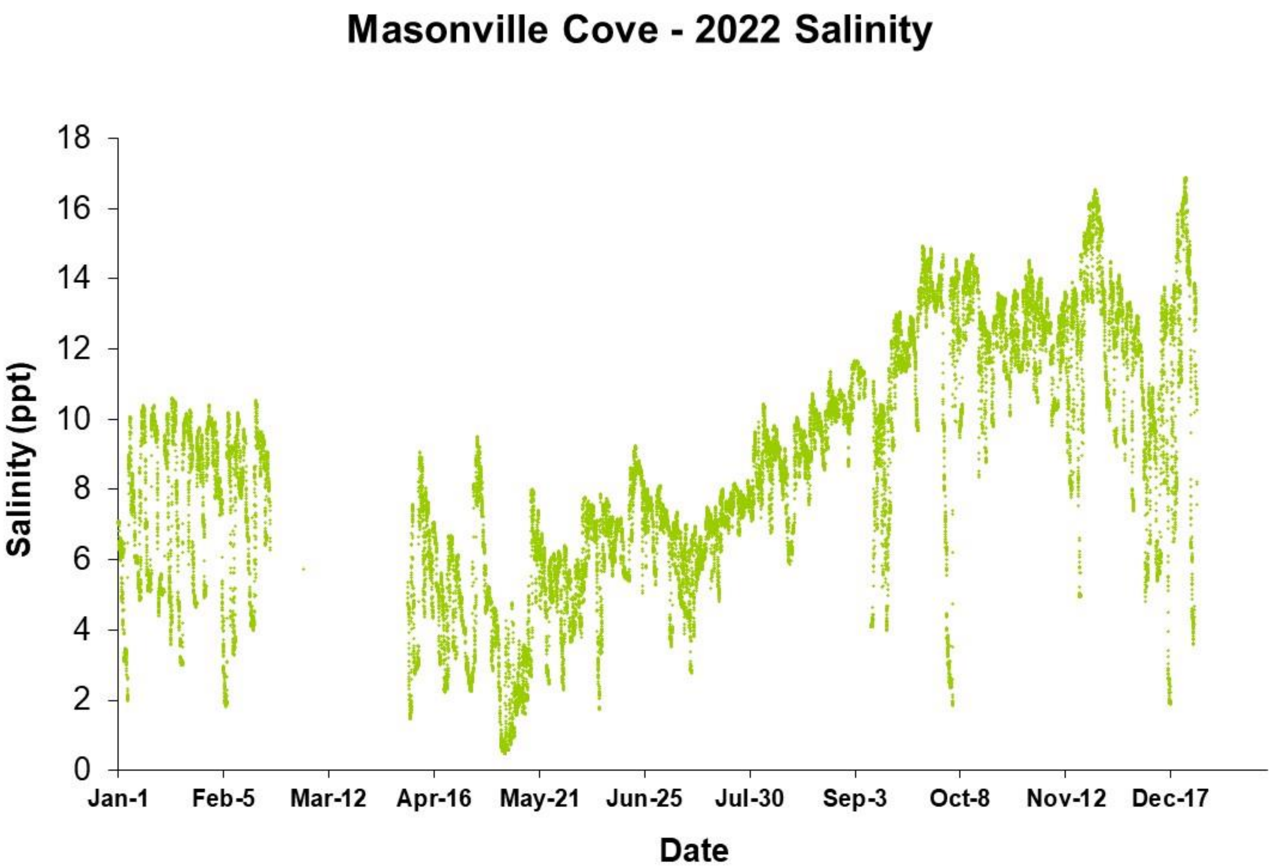

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2022.

Dissolved oxygen

Dissolved oxygen (DO) values remained high through mid-winter before the deployed water quality monitoring sondes malfunctioned, which precluded data collection between February 20th and April 7th (Figure 7). In early spring, DO levels continued to remain relatively high until mid- to late May, when DO concentration peaked to its highest levels (21.6 mg/L; 271% saturation) in 2022, which coincided with the presence of a severe algal bloom (Figure 8) within Masonville Cove. 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.

Throughout the year, algal blooms coincided with super-saturated DO concentrations in early June (16.8 mg/L; 204% saturation), late June (15.1 mg/L; 190% saturation), early July (14.4 mg/L; 191% saturation), early August (13 mg/L; 177% saturation), late September (15.1 mg/L; 186% saturation), and early to mid-December (17 mg/L; 152% saturation). During algal blooms, DO can also drop to very low levels at night when photosynthesis ceases and oxygen is consumed through cellular respiration. This pattern was observed throughout the late spring through early fall as DO exhibited large swings in concentrations, with a substantial number of low 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).

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 throughout June (0.60 mg/L), in late July (0.49 mg/L), early to mid-September (0.51 mg/L) and early October (1.75 mg/L). Oxygen readings then increased again in 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. In 2022, DO failure rates increased for the fourth straight year and were the second highest since monitoring began in Masonville Cove in 2009 (Table 1). Concentrations were below 5 mg/L 47.6% of the time and below 3.2 mg/L for 24.6% of readings. Both of these failure rates were markedly higher than the average annual failure rate over the prior 13 years of monitoring (34.5% for 5 mg/L; 15.8% for 3.2 mg/L).

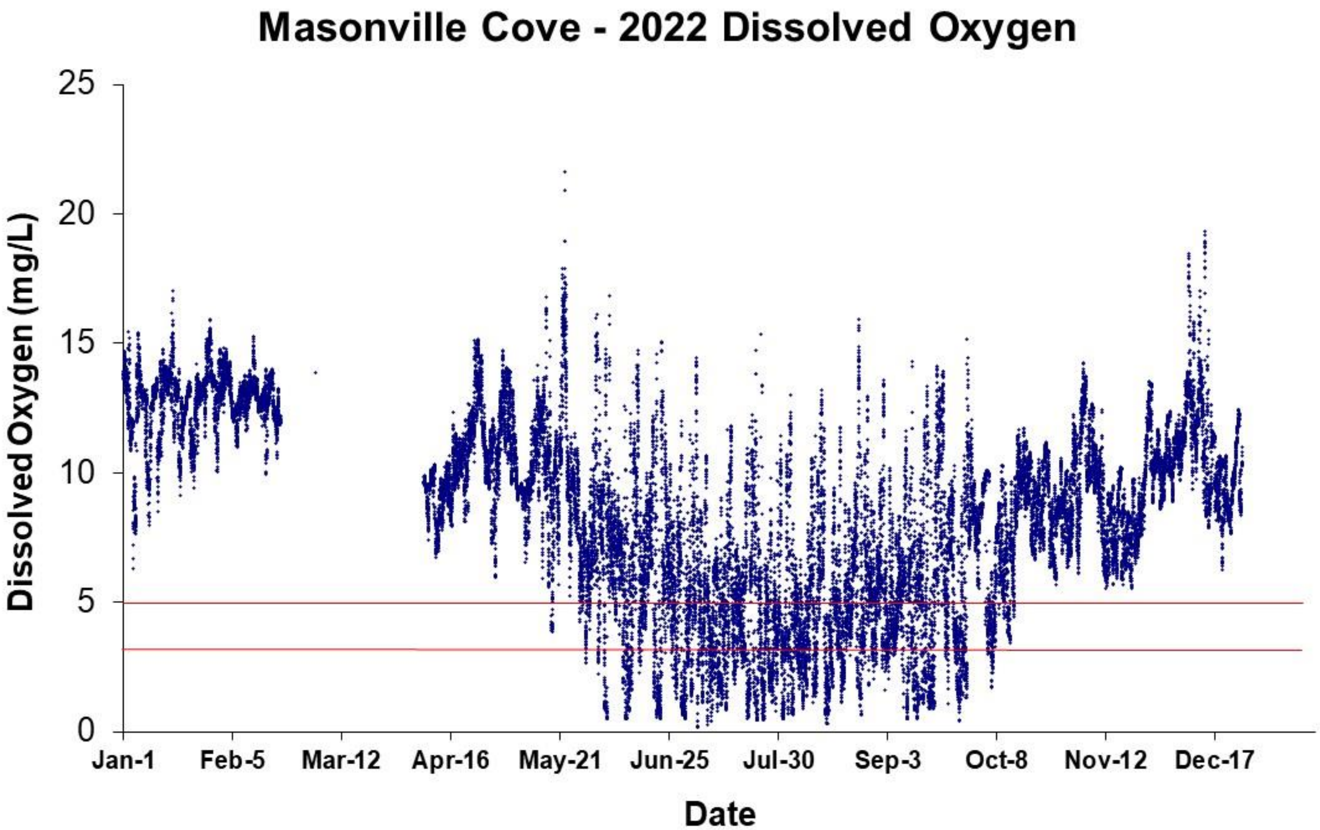

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2022. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove Continuous Monitor from June through September, 2009 to 2022.

DO	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	**2022**
< 5 mg/L	27.3%	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%**
< 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%**

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 ten of the twelve months in 2022 (Figure 8).

Chlorophyll sonde data indicate severe bloom conditions within Masonville Cove starting in early January as concentrations spiked to almost 300 µg/L (Figure 8). Significant bloom conditions continued through January into mid-February, before sonde malfunctions precluded data collection until early April. When data collection resumed on April 7th, chlorophyll readings were initially suppressed following heavy rains in early April, before rising to significant bloom conditions at the end of the month. Sonde readings indicate that numerous significant to severe algal blooms then occurred in Masonville Cove through the late spring and summer and into the fall. Measurements exceeded concentrations indicative of severe blooms conditions each month during this time, specifically in mid-May (331 µg/L), early June (361 µg/L), late June (321 µg/L), early July (162 µg/L), mid-July (174 µg/L), early August (276 µg/L), late August (128 µg/L), and late September (160 µg/L).

Chlorophyll concentrations then dropped to very low levels (less than 5 – 10 µg/L) during the first week of October as over 3.5 inches of rain fell on the region and flushed algae from Masonville Cove. Concentrations again dropped to low levels in mid-November. The most intense blooms of 2022 occurred in early and mid-December with observed chlorophyll concentrations approaching 500 µg/L, the maximum measurable value of the chlorophyll probes deployed in Masonville Cove. DNR field biologists that serviced the Masonville Cove station on December 13th observed that the water appeared brown and thick. Samples collected during this service visit indicated the presence of two potential harmful algal species, *Prorocentrum minimum* (9.9 million cells/L) and *Karlodinium sp.* (154,000 cells/L). Over two inches of rain fell on the region on December 15th and 16th, which led to an influx of freshwater and corresponded with a 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 2022 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 2022, chlorophyll exceedance rates decreased from the prior year, but still exceeded the long-term averages. Chlorophyll levels exceeded the 15 µg/L threshold during 46.2% of readings and exceeded the 50 µg/L threshold during 6.2% of readings. The average annual rates between 2009 and 2021 are 42.6% for 15 µg/L and 5.9% for 50 µg/L.

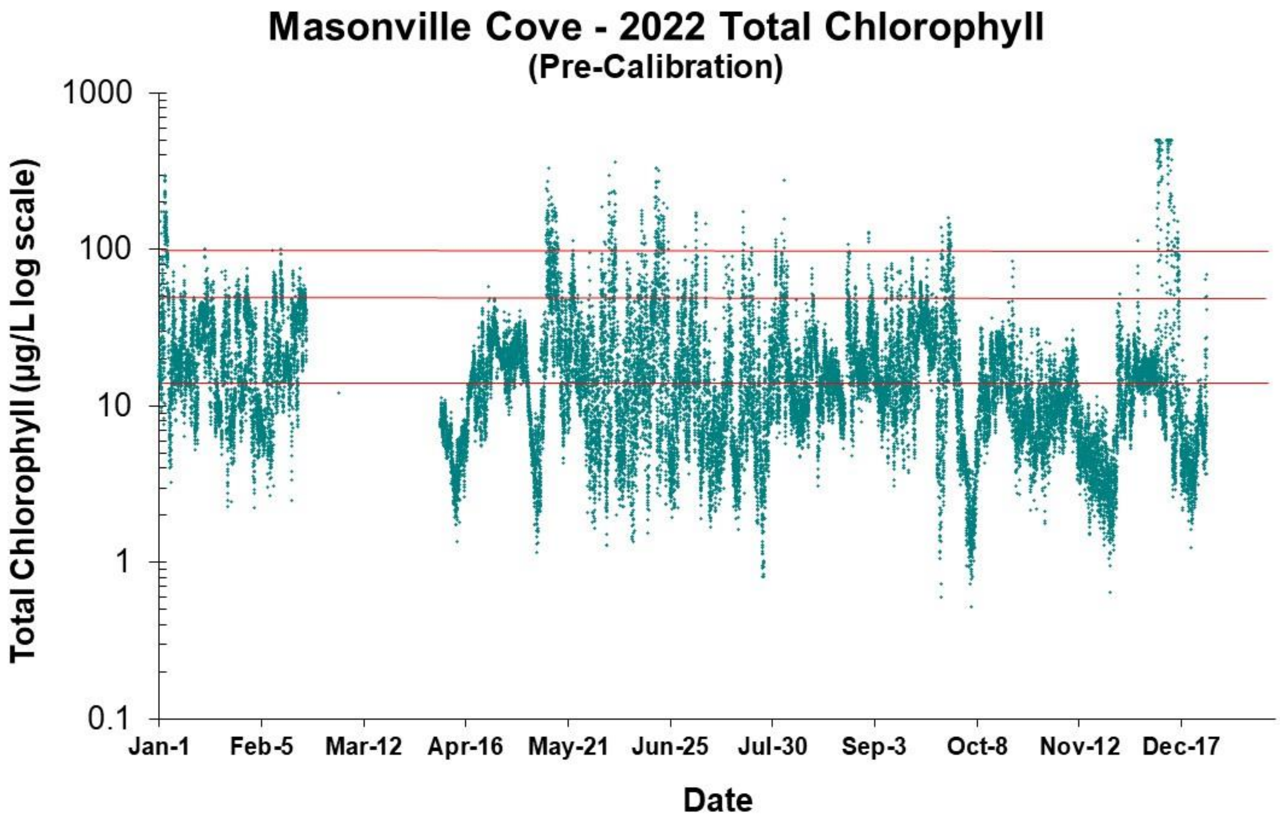

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2022. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 µg/L—are considered significant blooms—50 µg/L—or are considered severe blooms—100 µg/L.)*

Table 2. Chlorophyll threshold failure at Masonville Cove Continuous Monitor during June through November, 2009, March through October, 2010 to 2019 and 2021 to 2022, 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**
> 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%**
> 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%**

*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 2022, pH values exceeded 9 during significant to severe algal blooms in mid- to late May and mid-December (Figure 9). The highest pH reading of the year (9.3) occurred on May 22nd (Figure 8).

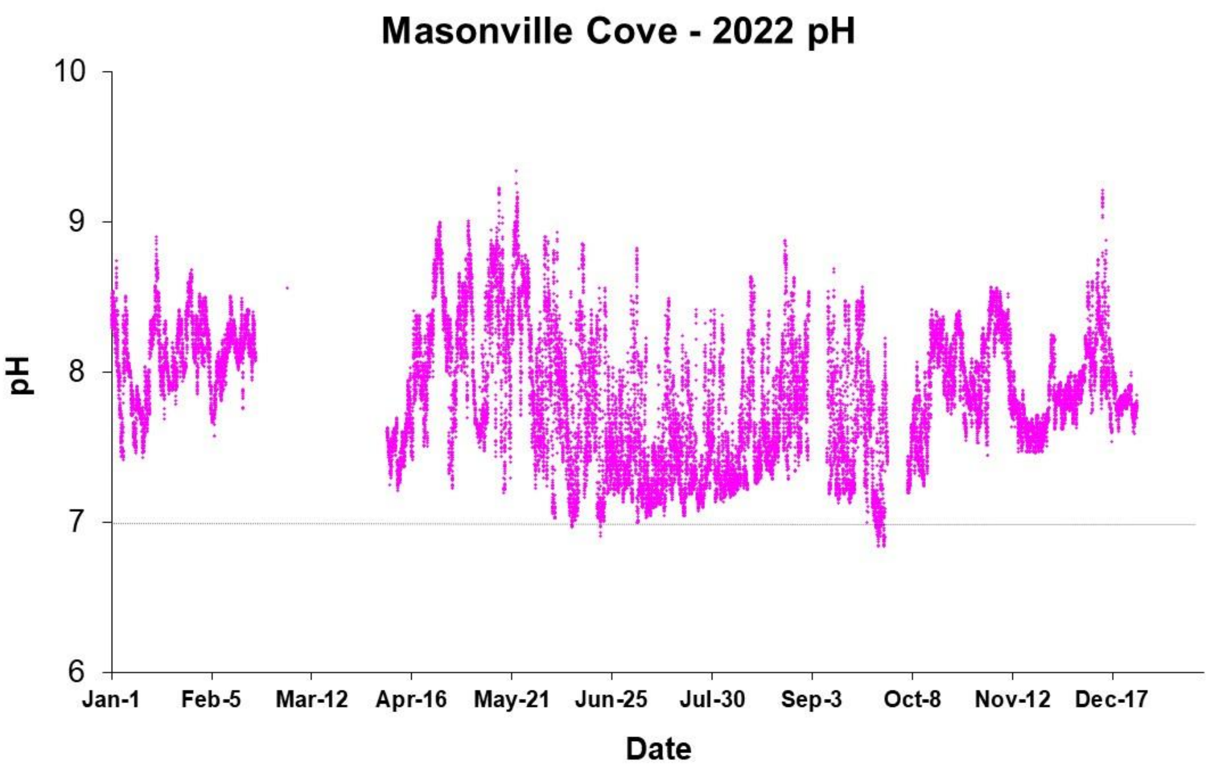

Figure 9. pH levels at Masonville Cove Continuous Monitor during 2022. *(Line indicates neutral pH.)*

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 the year, turbidity levels spiked extremely high to more than 100 NTU for short periods of time during late June and late September (Figure 10). Readings also spiked at other times during the year, generally following precipitation events, but the majority (60%) of turbidity values throughout the year were at or below 7 NTU (mean value: 9.6 NTU; median value: 5.8 NTU).

In winter, turbidity measurements spiked to above 40 NTU in January and February, before sonde malfunctions precluded data collection between late February and early April. When data collection resumed on April 7th, there were numerous spikes during the wetter than normal April and May (Figure 3). Readings were generally lower during dry periods of late May and early June, before spiking to 62 NTU on June 8th following heavy rains.

Reading generally remained below 20 NTU during July, August, and much of September, before spiking to the highest concentrations of the year in late September. The highest reading of the year (316 NTU) occurred following rains on September 22nd. Following the heavy rains and associated discharge event in early October, readings were generally below 7 NTU for the rest of the month through November. Readings then spiked to at least 50 NTU during the algal blooms and heavy rains in December.

Turbidity measurements above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. During the 2022 growing season, turbidity readings exceeded the 7 NTU threshold during 50.1% of readings (Table 3). This annual exceedance rate was slightly higher than the 2021 rate, but matched the average rate over the prior 13 years of monitoring (50.2%) and was the fifth lowest annual rate since monitoring began in Masonville Cove.

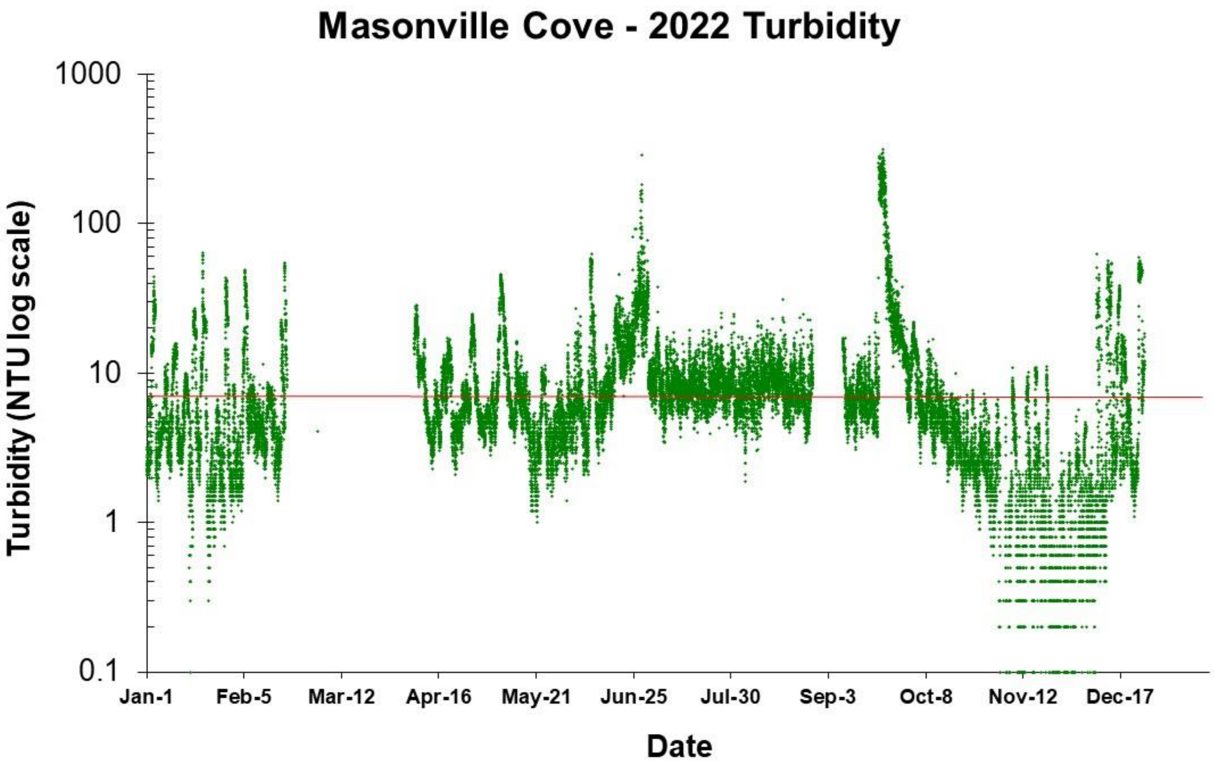

Figure 10. Turbidity levels at Masonville Cove Continuous Monitor during 2022. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failure at Masonville Cove Continuous Monitor during June through December, 2009, March through October, 2010 to 2019 and 2021 to 2022, 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**
> 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%**

*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 2022.

The total area of SAV within the Patapsco River in 2022 was 177 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 2022 increased for the sixth 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 2022, the total area of SAV within the Patapsco River system increased 7.5% 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 45% of the total restoration goal of 389 acres.

The increase in SAV coverage seen in the Patapsco River system since 2016 is in contrast to the recent trends found throughout the Chesapeake Bay watershed. Reductions of SAV beds have been recorded in many tributaries over the past few years. Bay-wide, SAV coverage declined 40% between 2017 and 2020, but have increased by almost 23% over the last two years. Approximately 77,000 acres were observed bay-wide in 2022, which is 42% 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/2022/.

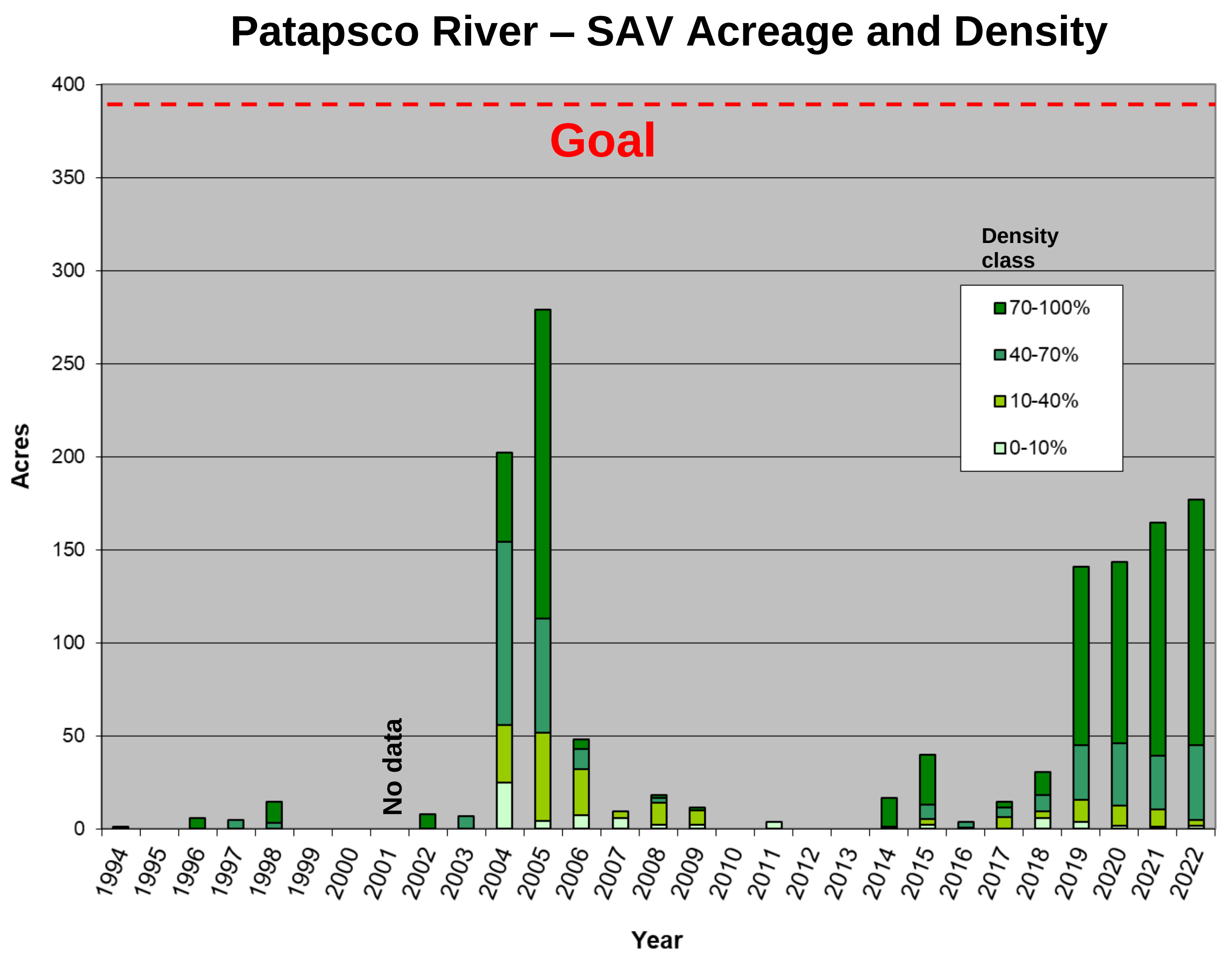

Figure 11. Total area and density of SAV in the Patapsco River between 1994 and 2022. (*Restoration goal is 389 acres)*

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. Secchi depth, a measure of water clarity, was also recorded at the Masonville Cove station each time a grab sample was collected.

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_2022_2023_Draft_v7.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 2022.

Scheduled calibration date	Samples collected	Comment
January 14th, 2022	Yes	
February 3rd, 2022	Yes	Ice covered approximately 95% of Masonville Cove
March 3rd, 2022	Yes	Telemetry data reestablished following a malfunction beginning on February 20th
April 7th, 2022	Yes	Telemetry data reestablished following a malfunction beginning on March 17th
April 19th, 2022	Yes	
May 5th, 2022	Yes	
May 19th, 2022	Yes	
June 1st, 2022	Yes	
June 13th, 2022	Yes	
June 30th, 2022	Yes	
July 14th, 2022	Yes	
July 27th, 2022	Yes	
August 11th, 2022	Yes	
August 24th, 2022	Yes	
September 8th, 2022	Yes	
September 20th, 2022	Yes	
October 6th, 2022	Yes	
October 20th, 2022	Yes	
November 3rd, 2022	Yes	
December 13th, 2022	Yes	Water appeared brown and thick; algal samples collected

Pigments

Chlorophyll concentrations at Masonville Cove started off above 40 µg/L in January 2022 but dropped and stayed below 20 µg/L through April 2022 (Figure A-1). In the months that followed, chlorophyll values increased but generally remained below 50 µg/L throughout the year. Two exceptions were a June peak of 111 µg/L chlorophyll in mid-June and a very high peak of 886 µg/L chlorophyll in mid-December.

Pheophytin values in 2022 showed a general pattern of lower values in the winter and spring, with more elevated concentrations in the summer and fall consistent with data collected in previous seasons (Figure A-2). January-March and October-November pheophytin concentrations were all less than 5 µg/L. Pheophytin concentrations showed three peaks in 2022: an early May peak of 10 µg/L, a higher peak of 15 µg/L in September, and a large peak of 37 µg/L in mid-December, which tracked with the chlorophyll peak.

Suspended solids

In 2022, suspended solids concentrations ranged between 6-93 mg/L at Masonville Cove (Figure A-3). Suspended solids concentrations remained less than 20 mg/L except for a peak of 29 mg/L in September and a large peak of 93 mg/L in December. The December 2022 peak coincided with peak measurements of chlorophyll/pigments and a corresponding decrease in Secchi depth.

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 2022 (0.1 m) was recorded on December 13, 2022, a date when high peak values of total suspended solids and chlorophyll/pigments were observed (Figure A-4). The highest Secchi depth value in 2022 (1.3 m) occurred on February 3rd.

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 highest salinities at Masonville Cove during 2022 were observed in October. The highest value was 14.3 ppt and salinities remained in this range (13-14 ppt) until December. The lowest daily mean salinity (2.6 ppt) occurred on May 5th. Some stratification of the water column was evident in the salinity readings in early September with surface and bottom readings differing by close to 7 ppt. Another stratification event was observed during the December 13th sampling when surface and bottom water salinities differed by 5 ppt.

Dissolved oxygen

Dissolved oxygen concentrations greater than 5 mg/L are considered necessary to support a healthy marine ecosystem. Following typical seasonal patterns for Chesapeake Bay, daily mean values of dissolved oxygen at Masonville Cove were higher in the winter and spring and low during most of the summer into the fall (Figure A-6). In contrast to 2021, mean daily dissolved oxygen levels in 2022 did not stay consistently above 5 mg/L. Hypoxic concentrations (< 2 mg/L) were measured during June, July, August, and September with the lowest concentration measured in bottom water on August 11th (0.6 mg/L). In early July, dissolved oxygen concentrations rose to over 9 mg/L, which can indicate the presence of bloom conditions as dissolved oxygen concentrations reach high levels due to algal photosynthesis.

Water temperature and pH

Water temperatures varied seasonally at Masonville Cove (Figure A-7). Water temperatures stayed below 3 °C in January and February of 2022. In March water temperatures rose to 8 °C and continued to steadily warm through early August. The highest measured water temperature was 28.6 °C on August 11th. Water temperatures declined through the fall to about 5 °C on December 13, 2022.

Daily mean pH values at Masonville Cove ranged between 7.3 to 8.6 and matched the pattern of dissolved oxygen concentrations (Figure A-8). A peak in July had a measured value of just over 8 and coincided with a rise in dissolved oxygen concentrations supporting the possibility of algal bloom presence. Mean and individual depth measurements of pH rose again in December coinciding with increased chlorophyll/pigments and TSS.

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2022. 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 2022, algal and dissolved oxygen conditions were degraded as compared to prior years. Samples collected within Masonville Cove during algal blooms in December indicated the presence of two potentially harmful algal species. Finally, water clarity conditions in Masonville were similar to prior years and no submerged aquatic vegetation was found in the Cove. Thus, habitat conditions in Masonville Cove 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 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)**

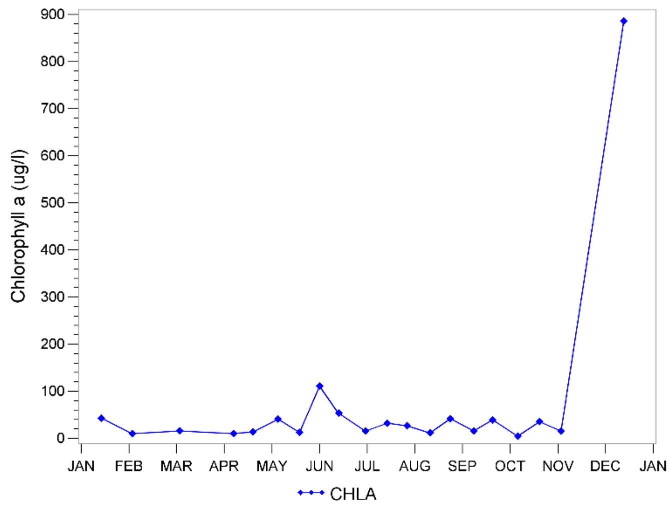

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2022.

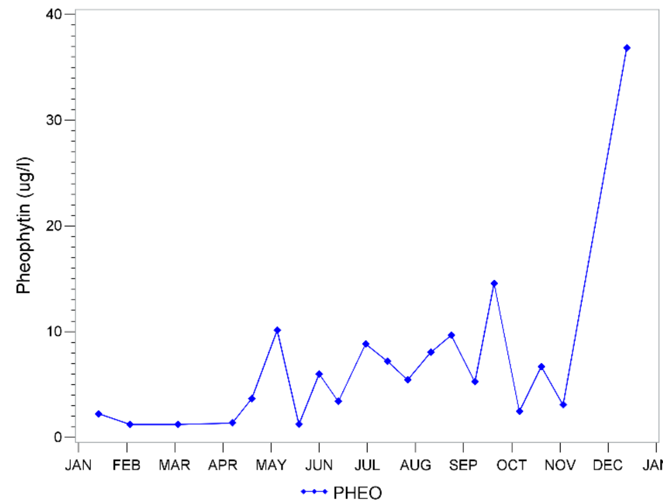

Figure A-2. Pheophytin concentrations at Masonville Cove in 2022.

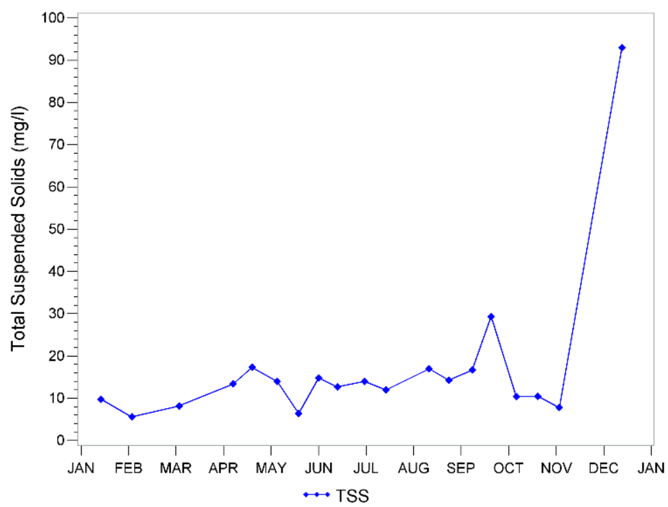

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2022.

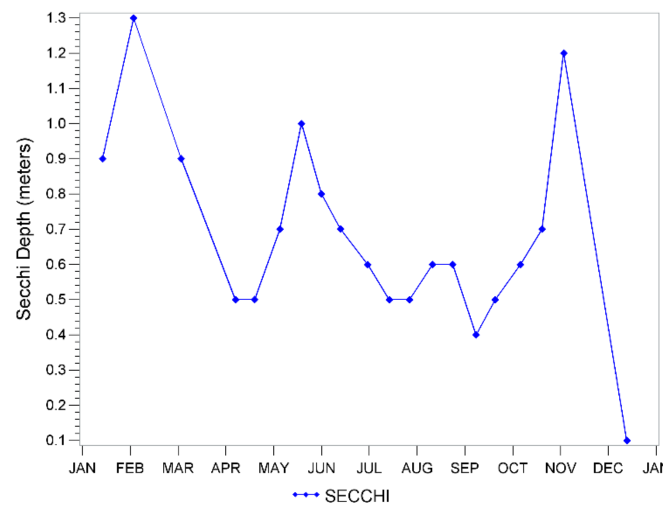

Figure A-4. Secchi depth at Masonville Cove in 2022.

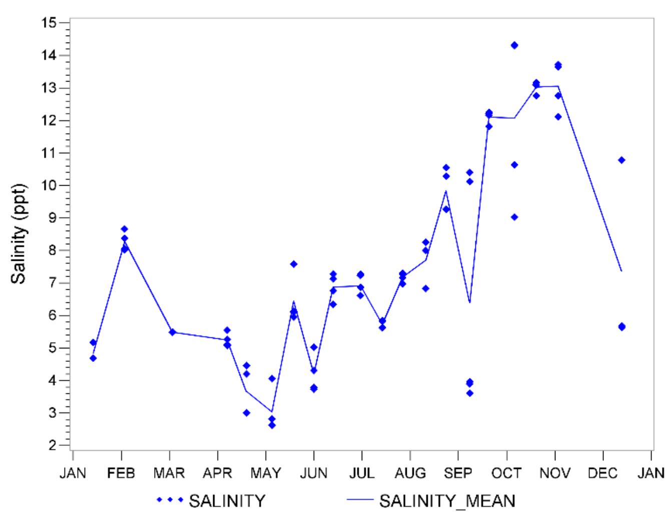

Figure A-5. Salinity concentrations at Masonville Cove in 2022.

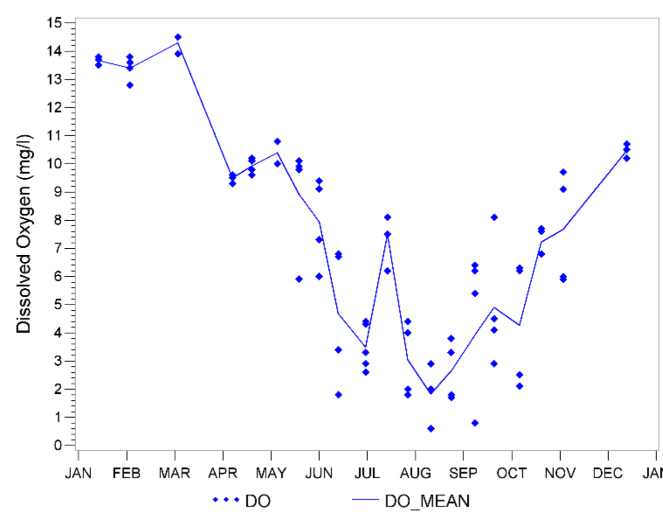

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2022.

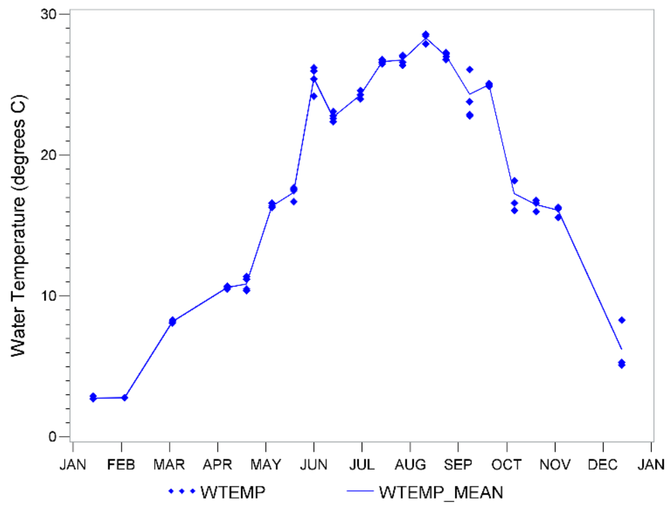

Figure A-7. Water temperature at Masonville Cove in 2022.

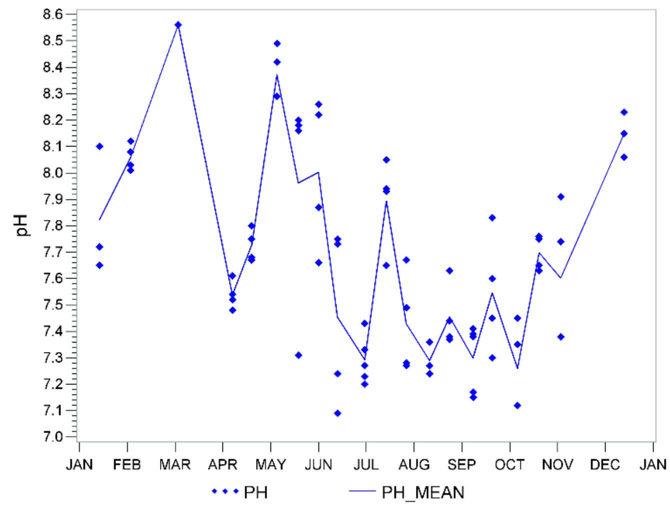

Figure A-8. Values of pH at Masonville Cove in 2022.

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 2022.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Pheophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
01/14/22	1	42.987	2.243	9.8	0.9
02/03/22	1	9.826	1.239	5.6[1]	1.3
03/03/22	1	15.806	1.239	8.2[1]	0.9
04/07/22	1	10.324	1.388	13.4	0.5
04/19/22	1	13.528	3.667	17.3	0.5
05/05/22	1	40.94	10.146	14.0	0.7
05/19/22	1	12.816	1.239	6.4	1.0
06/01/22	1	110.805	6.008	14.8	0.8
06/13/22	1	53.4	3.418	12.7	0.7
06/30/22	1	15.379	8.843	14.0	0.6
07/14/22	1	32.04	7.209	12.0[1]	0.5
07/27/22	1	26.7	5.447	no data[2]	0.5
08/11/22	1	11.748	8.063	17.0	0.6
08/24/22	1	41.919	9.665	14.3	0.6
09/08/22	1	15.664	5.269	16.7	0.4
09/20/22	1	39.249	14.578	29.3	0.5
10/06/22	1	4.699	2.478	10.4	0.6
10/20/22	1	35.458	6.707	10.5	0.7
11/03/22	1	15.593	3.097	7.8	1.2
12/13/22	1	886.44	36.846	93.0	0.1

1) Poor replication between pads, mean reported.

2) Sample results rejected due to quality control criteria.

Table A-2. Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2022 (continued on next page).

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
01/14/22	0.5	13.7	7.65	4.68	2.7
01/14/22	1.0	13.5	8.10	4.68	2.7
01/14/22	1.4	13.8	7.72	5.17	2.9
02/03/22	0.5	13.8	8.08	8.06	2.8
02/03/22	1.0	12.8	8.12	8.02	2.8
02/03/22	1.5	13.6	8.03	8.38	2.8
02/03/22	1.9	13.4	8.01	8.66	2.8
03/03/22	0.5	14.5	8.56	5.49	8.2
03/03/22	1.0	13.9	8.56	5.48	8.3
03/03/22	1.5	14.5	8.56	5.48	8.1
04/07/22	0.5	9.6	7.54	5.11	10.7
04/07/22	1.0	9.6	7.61	5.08	10.7
04/07/22	1.5	9.5	7.52	5.26	10.6
04/07/22	1.8	9.3	7.48	5.55	10.5
04/19/22	0.5	10.1	7.75	3.00	10.5
04/19/22	1.0	10.2	7.80	3.01	10.4
04/19/22	1.5	9.8	7.68	4.20	11.2
04/19/22	2.0	9.6	7.67	4.46	11.4
05/05/22	0.5	10.8	8.42	2.62	16.6
05/05/22	1.0	10.8	8.49	2.63	16.3
05/05/22	1.5	10.0	8.29	2.82	16.4
05/05/22	2.1	10.0	8.29	4.06	16.3
05/19/22	0.5	9.9	8.18	5.95	17.7
05/19/22	1.0	10.1	8.20	6.11	17.6
05/19/22	1.5	9.8	8.16	6.13	17.5
05/19/22	2.1	5.9	7.31	7.59	16.7
06/01/22	0.5	9.1	8.26	3.74	26.2
06/01/22	1.0	9.4	8.22	3.78	26.0
06/01/22	1.5	7.3	7.87	4.31	25.4
06/01/22	2.2	6.0	7.66	5.03	24.2
06/13/22	0.5	6.7	7.73	6.34	23.1
06/13/22	1.0	6.8	7.75	6.76	22.8
06/13/22	1.5	3.4	7.24	7.13	22.6
06/13/22	2.2	1.8	7.09	7.27	22.4
06/30/22	0.5	4.3	7.33	6.61	24.6

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2022.

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
06/30/22	1.0	4.4	7.43	6.61	24.0
06/30/22	1.5	3.3	7.27	6.87	24.3
06/30/22	2.0	2.6	7.20	7.23	24.3
06/30/22	2.3	2.9	7.23	7.27	24.3
06/30/22	0.5	4.3	7.33	6.61	24.6
06/30/22	1.0	4.4	7.43	6.61	24.0
06/30/22	1.5	3.3	7.27	6.87	24.3
06/30/22	2.0	2.6	7.20	7.23	24.3
06/30/22	2.3	2.9	7.23	7.27	24.3
07/14/22	0.5	8.1	8.05	5.63	26.8
07/14/22	1.0	8.1	7.94	5.82	26.6
07/14/22	1.5	7.5	7.93	5.62	26.7
07/14/22	2.2	6.2	7.65	5.85	26.5
07/27/22	0.5	4.0	7.49	6.97	26.6
07/27/22	1.0	4.4	7.67	7.16	26.4
07/27/22	1.5	2.0	7.28	7.27	27.0
07/27/22	2.0	1.8	7.27	7.31	27.1
08/11/22	0.5	2.9	7.27	6.84	27.9
08/11/22	1.0	2.0	7.36	8.00	28.5
08/11/22	1.9	0.6	7.24	8.26	28.6
08/24/22	0.5	3.3	7.44	9.26	27.0
08/24/22	1.0	3.8	7.63	9.27	26.8
08/24/22	1.5	1.8	7.37	10.29	27.3
08/24/22	1.9	1.7	7.38	10.55	27.2
09/08/22	0.5	6.2	7.41	3.61	22.9
09/08/22	1.0	6.4	7.39	3.90	22.8
09/08/22	1.5	5.4	7.38	3.96	23.8
09/08/22	2.0	0.8	7.17	10.12	26.1
09/08/22	2.3	0.8	7.15	10.40	26.1
09/20/22	0.5	8.1	7.83	11.81	25.1
09/20/22	1.0	4.5	7.60	12.25	25.0
09/20/22	1.5	4.1	7.45	12.16	25.1
09/20/22	1.8	2.9	7.30	12.21	24.9
10/06/22	0.5	6.2	7.35	9.03	16.1
10/06/22	1.0	6.3	7.45	10.64	16.6

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2022.

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
10/06/22	1.5	2.1	7.12	14.31	18.2
10/06/22	2.0	2.5	7.12	14.33	18.2
10/20/22	0.5	7.7	7.76	12.76	16.0
10/20/22	1.0	7.6	7.75	13.17	16.6
10/20/22	1.5	6.8	7.65	13.09	16.8
10/20/22	2.0	6.8	7.63	13.10	16.6
11/03/22	0.5	9.7	7.91	12.11	15.6
11/03/22	1.0	9.1	7.74	12.76	16.2
11/03/22	1.5	5.9	7.38	13.65	16.3
11/03/22	1.9	6.0	7.38	13.72	16.3
12/13/22	0.5	10.7	8.15	5.63	5.3
12/13/22	1.0	10.5	8.23	5.68	5.1
12/13/22	1.6	10.2	8.06	10.78	8.3