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DEPARTMENT OF
NATURAL RESOURCES

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2020 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

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Executive summary

Masonville Cove, a small inlet of the upper tidal Patapsco River, figures in local Baltimore lore as a natural respite from the rigors of early 20th century city life. However, as the Patapsco River was heavily impacted by pollution from centuries of being a center of commerce and population, so too was Masonville Cove. In 2007, the Maryland Port Administration received a permit to build a dredged material containment facility at the Masonville Marine Terminal, adjacent to Masonville Cove. As part of the mitigation agreement for this project, the Maryland Department of Natural Resources (DNR) deployed a continuous water quality monitor in the summer of 2009, ahead of the construction of the dredged material containment facility. Since 2009, DNR has continued to deploy a monitor during most of the year, although it has been removed in the winter in some years due to icing conditions. In continuation of this project, a water quality monitor was deployed off the Masonville Cove pier during 2020.

Results from 2020 indicate poor, but some potentially improving habitat conditions in Masonville Cove. The year was wetter than normal overall, but runoff from precipitation did not lead to degraded water clarity as compared to prior years. Turbidity readings in 2020 improved to the lowest levels since monitoring began in Masonville Cove. Dissolved oxygen concentrations, however, degraded after improved conditions in the last few years. Algal concentrations and associated algal blooms also increased following two years of improving conditions. However, due to the COVID-19 pandemic and associated restrictions and mitigation strategies implemented by the State of Maryland, no water quality data were collected in Masonville Cove in April and May, 2020. These extenuating circumstances make water quality monitoring results between 2020 and prior years difficult to compare.

All 2020 continuous monitoring data, as well as data from previous years, are available on the DNR “Eyes on the Bay” website (http://eyesonthebay.dnr.maryland.gov/contmon/ContMon.cfm). Data from grab samples are available through the Chesapeake Bay Program’s Data Hub (https://www.chesapeakebay.net/what/data). The most recent seven days of water quality data can also be viewed on the “Eyes on the Bay” Masonville Cove webpage (http://eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm). Data collected in 2020 at the time of each instrument replacement (pigments, suspended solids, Secchi disk depth and ambient water quality data) are also available for download via the following link: http://eyesonthebay.dnr.maryland.gov/contmon/GetConMonDataHub_StationTable.cfm?station=XIE4742&DataHubID=1930&startdate=1-1-2020&enddate=12-31-2020.

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 2020, 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 three continuous monitoring stations located in the upper Patapsco in 2020. The other two sites were deployed adjacent to the National Aquarium in the Baltimore Harbor.

Description of continuous monitoring

In 2020, 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.

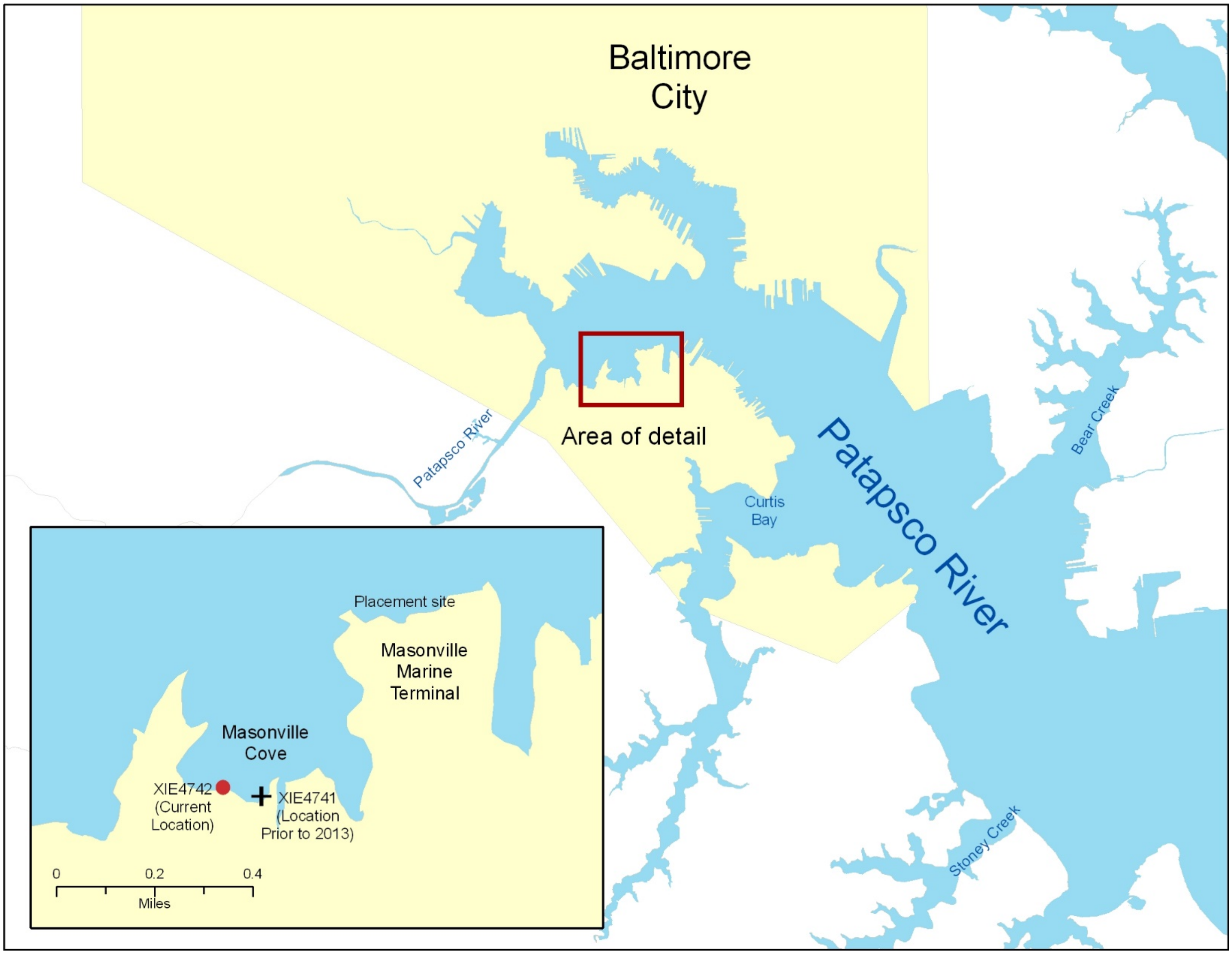

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2020 continuous monitor location within the cove, the location of the monitor prior to 2013 and the approximate site for dredged material placement.

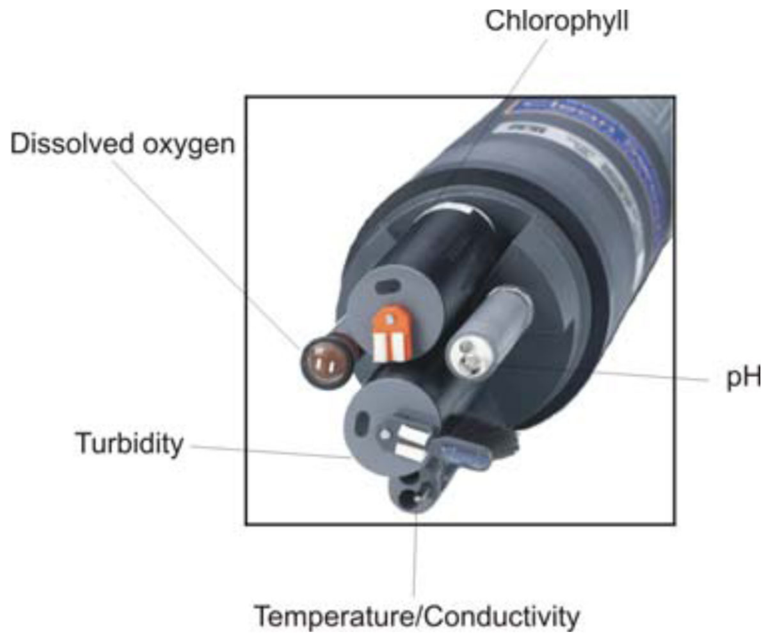

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

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 higher turbidities. Relatively clear water (low turbidity) is required for the growth and survival of submerged aquatic vegetation (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 2020, a continuous monitor at Masonville Cove was deployed the entire year. Data sondes collected 27,716 data records and 14 calibration samples were collected and analyzed in 2020.

Generally, calibration samples are collected when sondes are changed out every two weeks between April and October and every four weeks between November and March. However, DNR field personnel were unable to service the station between February 4th and June 9th. On February 26th, the United States Fish and Wildlife Service began enforcing no entry zones within the property adjoining Masonville Cove due to the presence of nesting bald eagles. Furthermore, due to the COVID-19 pandemic and the State of Emergency declared by Governor Hogan, DNR suspended all field-related activities between March 13th and May 26th. The sonde deployed during this time suffered a power failure on March 25th and no water quality data were collected until limited-service visits to Masonville Cove resumed on June 9th. Twice a month service visits to Masonville Cove resumed in July.

Because water quality sonde data were not collected during April and May, the time period used to calculate criteria and threshold failure rates for chlorophyll and turbidity (Tables 1-3) were adjusted in 2020 and do not match the time periods used to calculate these rates in prior years.

A power failure to the water quality monitoring sonde also precluded data collection between September 15th and September 16th. Additional gaps seen in the data are where questionable data were removed for quality assurance purposes. Automated telemetry generally operated when deployed, but there were times when telemetry did not work properly, which led to gaps in near real-time web presentation of the data. Telemetry issues did not, however, impede the sonde from collecting data.

2020 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 2020 at Baltimore Washington International (BWI) Thurgood Marshall Airport was 12.38 inches above the 30-year average (Figure 3). Total precipitation surpassed monthly averages in 9 of the 12 months and over half of the total annual precipitation fell in the four wettest months (April, June, August, and November). August was the wettest month in 2020 with 11.81 inches of rain and was the third wettest August on record. These totals were fueled by Tropical Storm Isaias, which impacted the region August 3rd-4th, and heavy rains over six successive days mid-month that dropped over six inches of rain on the region. Precipitation during August was associated with numerous sanitary sewer overflows throughout the Patapsco River watershed, which spilled over five million gallons of untreated, diluted wastewater throughout Baltimore City and County. November was the second wettest month of 2020 and rains mid-month led to over four million gallons of wastewater being spilled into the watershed via sanitary sewer overflows. In addition to heavy rains leading to sewage discharges, the Patapsco Wastewater Treatment Plant was found to have exceeded sewage discharge and associated limits of harmful bacteria, phosphorus, nitrogen, and total suspended solids beginning in July 2020 through the end of the year.

Daily mean discharge at the United States Geological Survey (USGS) gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2020 (Figure 4). Gage data show numerous spikes throughout 2020, which are indicative of the precipitation events that affected the region during the year. The largest flow of the year occurred on April 13th following heavy rains that dropped over two inches on the region. This flow event was more than 1000 cubic feet per second (cfs) greater than the daily median measured over 56-years, reflecting very high discharge levels into the Patapsco River and the Chesapeake Bay. Extremely high flows more than 400 cfs greater the daily median were also measured following heavy rains on January 25th, April 30th, August 4th, November 30th, and December 25th. Flows in July, one of the drier months of 2020, were generally below the daily median.

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

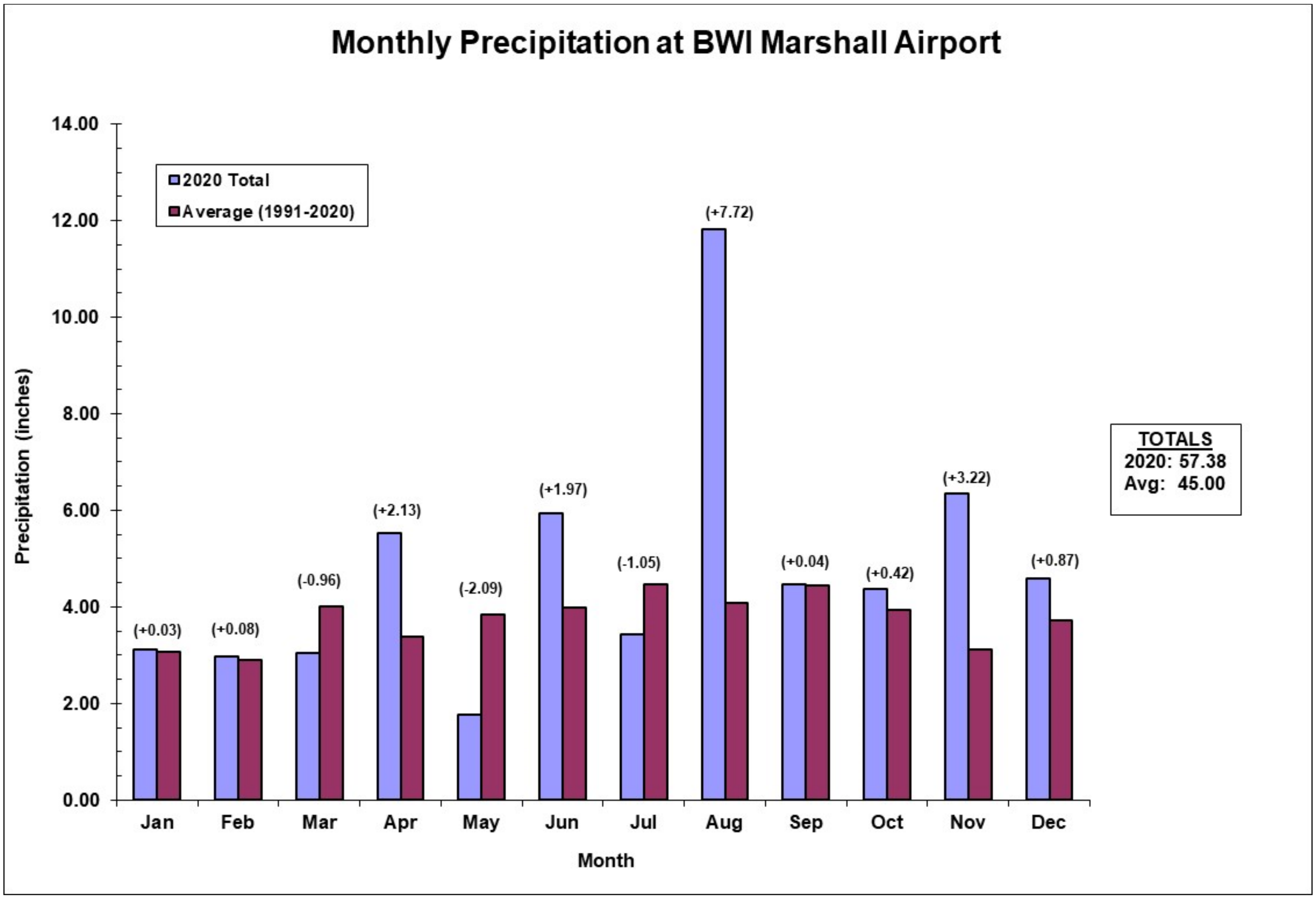

Figure 3. Total 2020 monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages. Data source: National Weather Service (weather.gov/media/lwx/climate/bwiprecip.pdf).

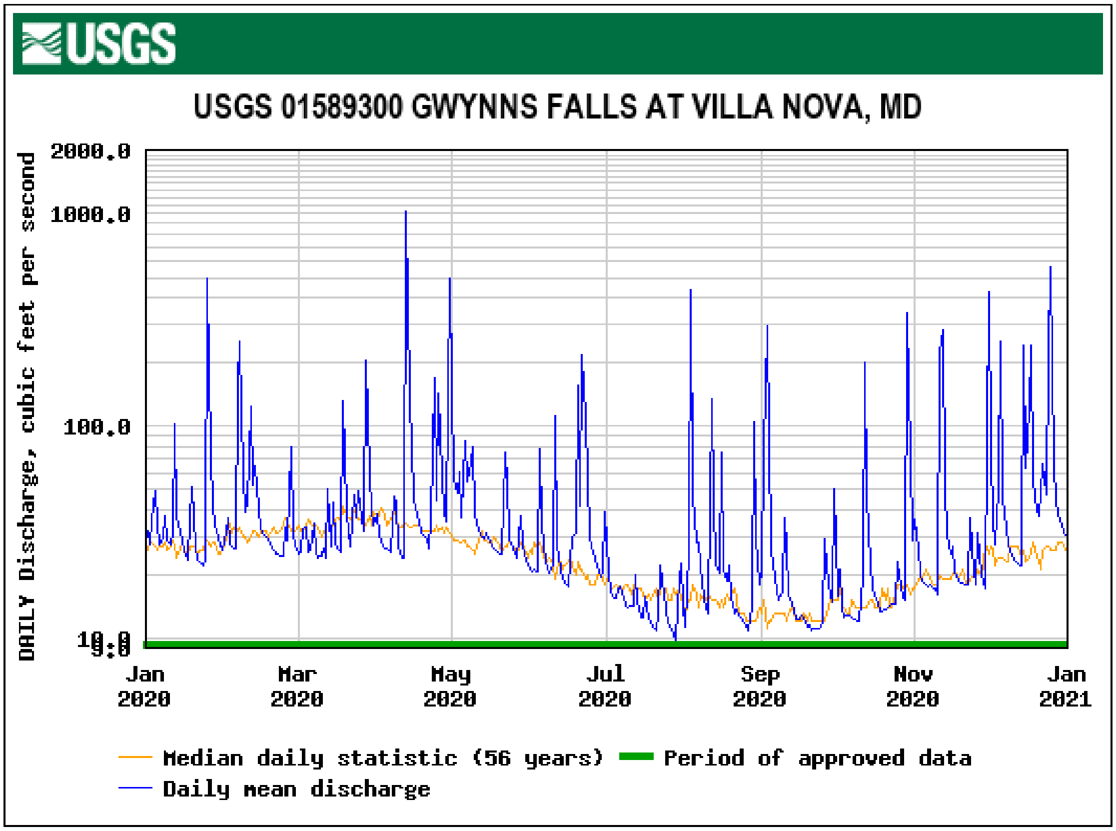

Figure 4. 2020 daily discharge in cubic feet per second measured at a USGS gaging station northwest of Masonville Cove. Graph courtesy of the United States Geological Survey (https://waterdata.usgs.gov/nwis/dv/?site_no=01589300).

2020 Continuous Monitoring Data

Water temperature

Water temperature at Masonville Cove rose predictably during the first seven months of 2020 as air temperatures increased (Figure 5). Water temperatures peaked at 31.6°C (~89° F) in mid-August and generally remained between 25-28°C (77-82° F) through early September, before gradually declining with air temperatures through much of 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).

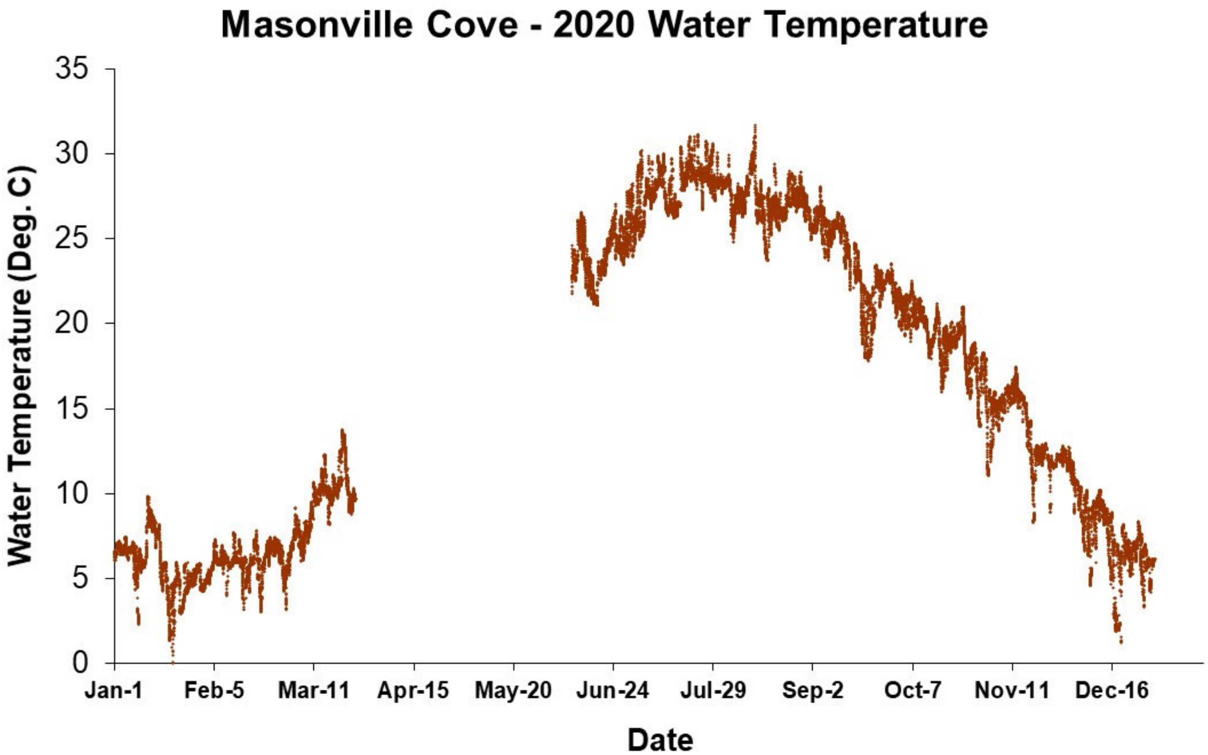

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2020. (No sonde data collected April-May.)

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 2020 (Figure 6) began with generally higher salinities in late winter. Concentrations then began to drop in March before the deployed water quality monitoring sonde lost power on March 25th. When data collection resumed on June 9th, salinity concentrations had dropped to approximately six parts per thousand (ppt). Concentrations rose during the drier than normal July before dropping again during the extremely wet month of August (Figure 3). The lowest concentration of 2020 (0.91 ppt) was recorded on August 13th. Salinity levels then rose into autumn, reaching a peak of 14.84 ppt on October 9th, before declining again during a wetter than normal November and December (Figure 3).

Salinity readings in Masonville Cove often quickly dropped 8-12 ppt, usually following a rain event, before quickly rebounding to prior levels (Figure 3). 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.

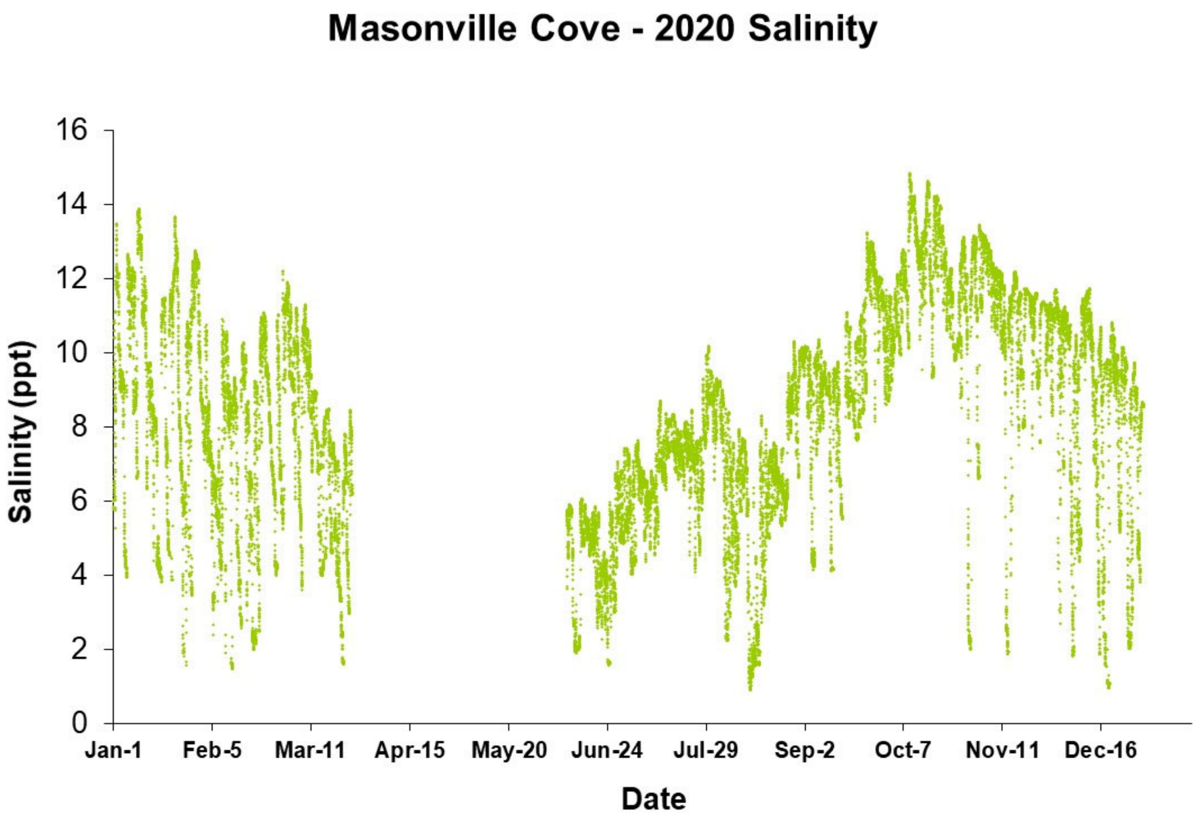

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2020. (No sonde data collected April-May.)

Dissolved oxygen

Dissolved oxygen (DO) values remained high through winter and early spring before the deployed water quality monitoring sonde lost power on March 25th (Figure 7). In mid to late January, DO concentration peaked to its highest levels (18.5 mg/L; 136% saturation) in 2020, which coincided with the presence of an 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. This pattern was evident when data collection resumed in Masonville Cove on June 9th.

Numerous algal blooms throughout the summer and early fall led to super-saturated DO concentrations in mid-June (13.1 mg/L; 158% saturation), early July (14.7 mg/L; 196% saturation), mid to late August (16.2 mg/L; 219% saturation), mid-September (14.7 mg/L; 173% saturation), and early October (14.8 mg/L; 176% saturation). During algal blooms, however, DO can drop to very low levels at night when photosynthesis ceases and oxygen is consumed through cellular respiration. This pattern was observed throughout the summer and 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 die back of algal blooms, coincided with large drops in DO concentrations in late June (0.98 mg/L), mid-July (0.94 mg/L), early September (0.34 mg/L), and mid-October (3.72 mg/L).

Oxygen readings gradually increased in the fall and early winter as water temperature cooled (Figure 5). This pattern is expected 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 2020, DO failure rates were the highest in the last three to four years (Table 1). Concentrations were below 5 mg/L 39% of the time and below 3.2 mg/L for 20% of readings. Both of these rates were greater than the average failure rate over the prior 11-years of monitoring (14.9% for 3.2 mg/L; 33.4% for 5 mg/L). These degraded oxygen conditions in Masonville Cove may be related to the higher algal concentrations recorded in 2020 as compared to the prior two years (Table 2).

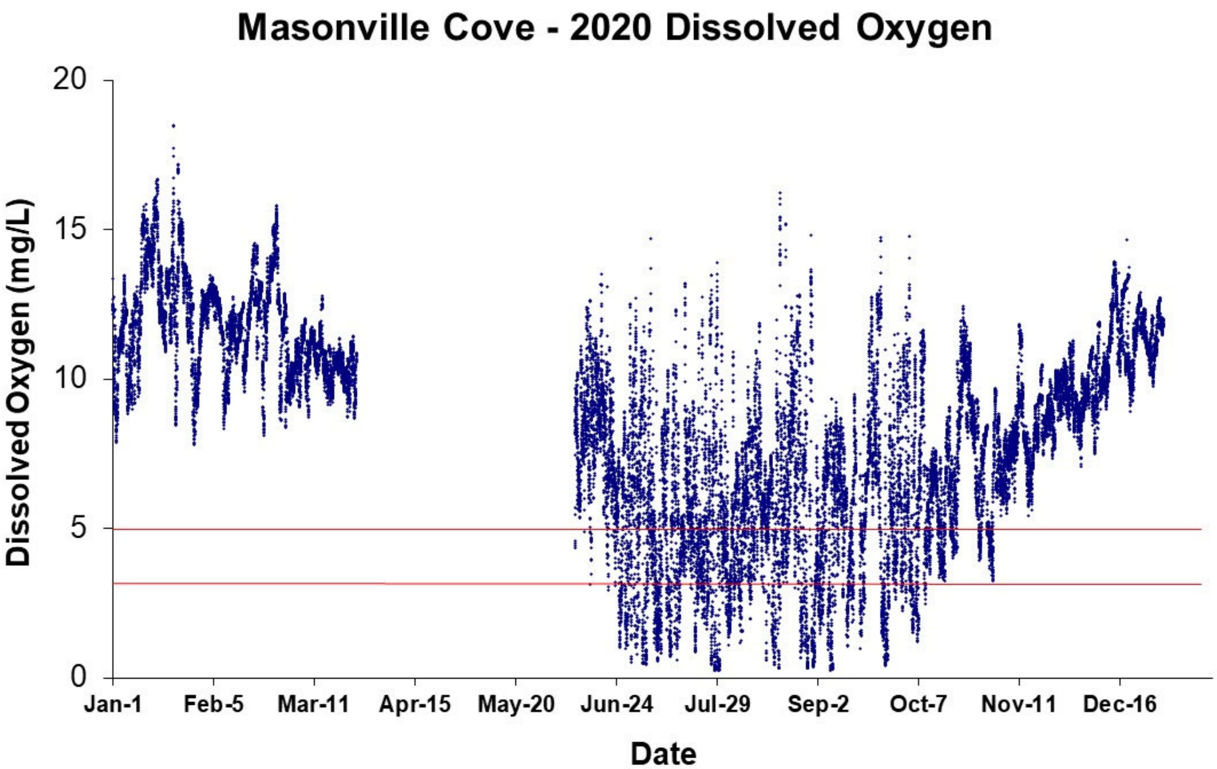

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2020. (No sonde data collected April-May.) (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove Continuous Monitor during June through September, 2009 to 2020.

Dissolved Oxygen	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	**2020**
Less than 5 mg/L	27.3%	36.0%	28.1%	37.0%	37.8%	33.7%	39.1%	48.1%	38.3%	18.2%	23.7%	**39.0%**
Less than 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%**

Chlorophyll

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

Chlorophyll data indicate significant to severe bloom conditions within Masonville Cove through much of January (Figure 8). Samples collected from Masonville Cove by DNR biologists on January 7th indicated the presence of *Prorocentrum minimum* (4,928 cells/mL), a potentially harmful algal bloom species, as well as a bloom of *Heterocapsa spp*. (226,688 cells/mL). Concentrations peaked at 167 µg/L on January 22nd, before 1.5-inches of rain fell on the region at the end of the month and flushed algae from Masonville Cove. Chlorophyll concentrations again increased to bloom levels in mid- to late February, before dropping and remained below 50 µg/L the remainder of the time before the deployed water quality monitoring sonde lost power on March 25th.

Following resumption of data collection on June 9th, chlorophyll readings indicate several significant algal blooms throughout June. Samples collected by DNR biologists on June 9th upstream (1,232 cells/mL) and downstream (9,856 cells/mL) of Masonville Cove indicated the presence of *Prorocentrum minimum* throughout the Patapsco River. Significant to severe bloom conditions within Masonville Cove continued into July. Samples collected on July 9th by DNR biologists downstream of Masonville Cove indicated the presence of two potentially harmful algal species, *Prorocentrum minimum* (47 cells/mL) and *Karlodinium veneficum* (95 cells/mL) within the Patapsco River. Bloom conditions continued through August and summer chlorophyll concentrations peaked at over 160 µg/L on August 30th. The highest chlorophyll reading of 2020 (203 µg/L) was recorded during significant to severe bloom conditions in late September and early October. Samples collected on October 1st by DNR biologists upstream of Masonville Cove indicated the presence of *Prorocentrum minimum* (112 cells/mL). On October 11th-12th, 1.4-inches of rain fell on the region and another 2.2-inches fell at the end of October. These rain events flushed algae from Masonville Cove and chlorophyll readings generally remained below 15 µg/L for the remainder of the year.

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 2020 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 2020, chlorophyll levels exceeded the 15 µg/L threshold during 43.2% of readings and exceeded the 50 µg/L threshold during 4.5% of readings (Table 2). These increases in failure rates followed two years of improving algal conditions within Masonville Cove, and the 15 µg/L failure rate for 2020 was higher than the average rate over the prior years of monitoring (41.8% for 15 µg/L; 5.6% for 50 µg/L). However, any comparisons and interpretations in chlorophyll results between 2020 and prior years should be made with the caveat that, because water quality sonde data were not collected during April and May, the time period used to calculate threshold failure rates for chlorophyll were adjusted in 2020 and do not match the time periods used to calculate those rates in prior years.

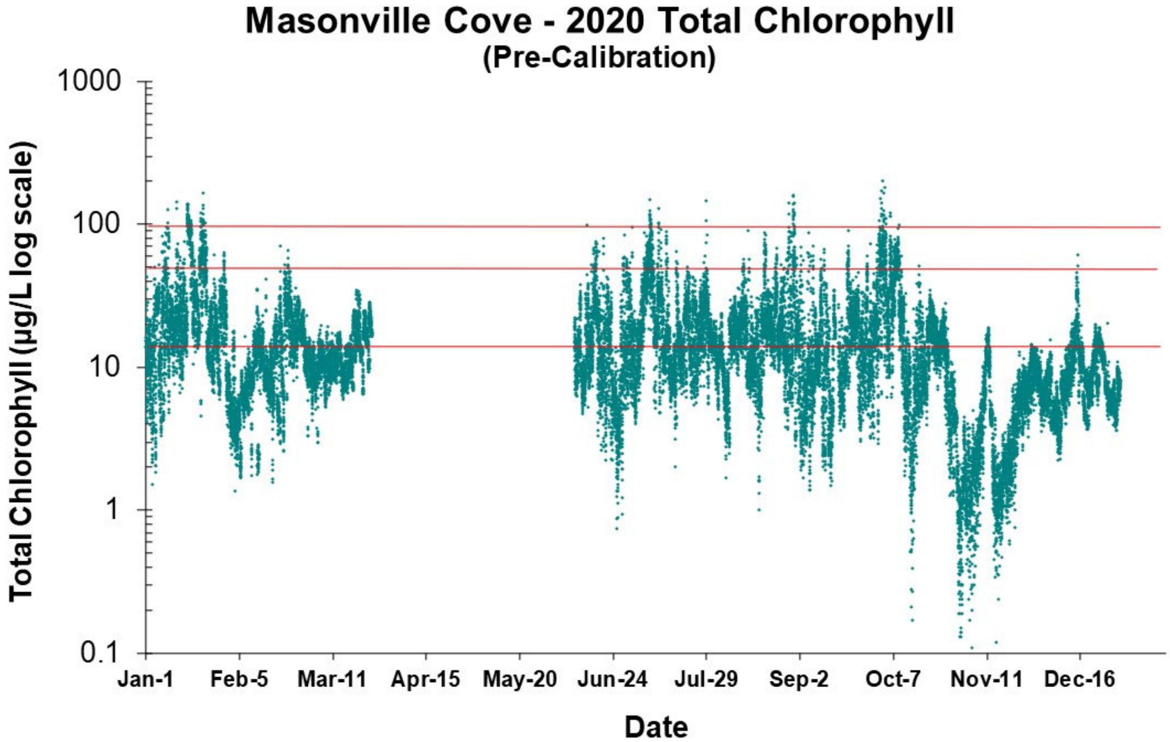

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2020. (No sonde data collected April-May.) *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 mg/L—are considered significant blooms—50 mg/L—or are considered severe blooms—100 mg/L.)*

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

Chlorophyll	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	**2020**
Greater than 15 µg/L	37.4%	59.0%	38.8%	55.6%	52.1%	36.2%	43.1%	40.1%	46.4%	23.3%	27.6%	**43.2%**
Greater than 50 µg/L	3.3%	6.6%	0.9%	14.5%	10.5%	5.2%	8.9%	4.0%	5.5%	1.5%	1.0%	**4.5%**

pH

pH readings tend to fluctuate between 7 and 9 in most Chesapeake Bay tidal waters, with spikes above 9 indicating potential algal blooms. High pH in the absence of high chlorophyll also can indicate that a blue-green algal bloom may have occurred (the chlorophyll sensors on the continuous monitors deployed at Masonville Cove are not designed to detect the wavelengths emitted by cyanobacteria). No pH values exceeded a value of 9 in 2020 at Masonville Cove (Figure 9). The highest pH reading of the year (8.9) occurred during significant to severe bloom conditions in January (Figure 8). Elevated pH values greater than 8.5 were also recorded during algal blooms in mid-June, mid-July, mid-August, and late September.

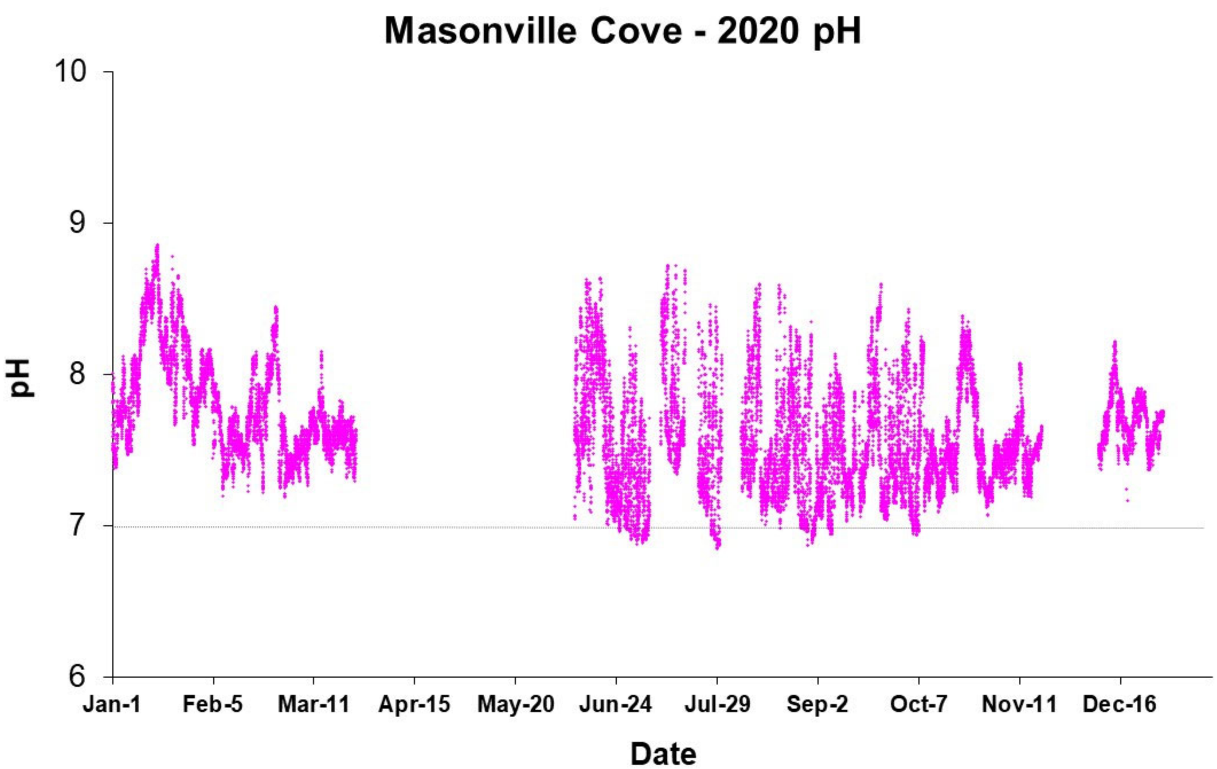

Figure 9. pH levels at Masonville Cove Continuous Monitor during 2020. (No sonde data collected April-May.) *(Line indicates neutral pH.)*

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 (Figure 10) one time during the extremely wet August (Figure 3). Readings also spiked other times during the year, generally following precipitation events, but the majority (74%) of turbidity values throughout the year were at or below 7 NTU (mean value: 6.2 NTU; median value: 4.2 NTU).

In January, turbidity measurements spiked to approximately 35 NTU on January 5th following a rain event and to 77 NTU, coinciding with severe algal bloom conditions, on January 17th. Readings spiked once more to greater than 50 NTU in early March (52 NTU) following rain in the region, before the deployed water quality monitoring sonde lost power on March 25th.

Following the resumption of data collection on June 9th, turbidity readings generally remained below 20 NTU, before spiking to 52 NTU during a rain event on July 21st. In August, readings jumped to 45 NTU following Tropical Storm Isaias, and the highest turbidity reading of 2020 (145.4 NTU) occurred on August 13th following heavy rains and associated sanitary sewer overflows in the Patapsco River watershed. Turbidity readings general ranged below 20 NTU through September and October, before spiking to 50 NTU in early November, following heavy rains associated with the remnants of Hurricane Zeta, which impacted the region on October 30th. In December, there were multiple spikes in turbidity to between 30 and 55 NTU as the region was impacted by multiple rain events.

One item of note is that turbidity data were censored from the published dataset between June 30th and July 9th, and between October 14th and October 29th because measurements collected during these times were considered suspect following the application of QA/QC protocols.

Turbidity measurements above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. During the 2020 growing season, turbidity readings exceeded the 7 NTU threshold during 34.3% of readings, which is the lowest rate observed since monitoring began in Masonville Cove (Table 3). This annual rate was also lower than the average rate over the prior 11-years of monitoring (51.7%). Thus, preliminary conclusions are that water clarity conditions improved in Masonville Cove in 2020. However, any comparisons and interpretations in turbidity results between 2020 and prior years should be made with the caveat that, because water quality sonde data were not collected during April and May, the time period used to calculate threshold failure rates for turbidity were adjusted in 2020 and do not match the time periods used to calculate those rates in prior years.

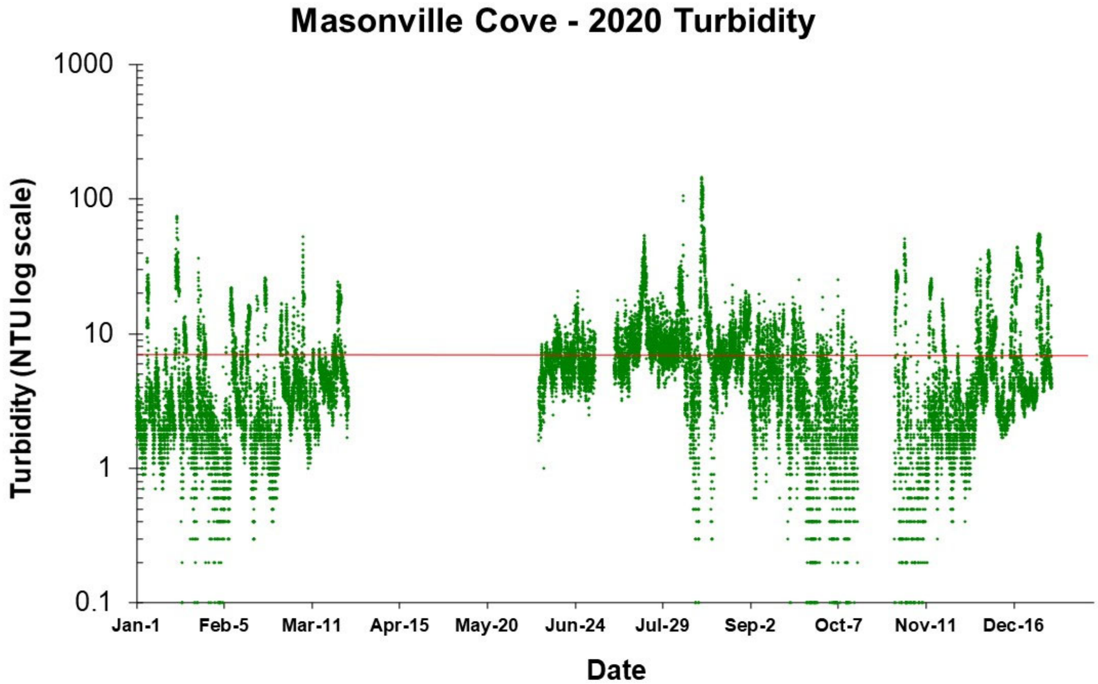

Figure 10. Turbidity levels at Masonville Cove Continuous Monitor during 2020. (No sonde data collected April-May.) *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

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

Turbidity	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	**2020**
Greater than 7 NTU	54.6%	60.1%	51.6%	35.0%	53.9%	52.9%	53.8%	34.9%	60.9%	53.8%	56.9%	**34.3%**

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 2020.

The total area of SAV within the Patapsco River increased 350% between 2018 and 2019. In 2020, the total area remained stable and stands at 36% of the total restoration goal of 389 acres. All 141 acres of observed SAV were located in tributaries of the river and SAV was absent within Masonville Cove and the mainstem of the Patapsco. Poor water clarity and lack of viable seed banks may explain the lack of SAV coverage within Masonville Cove. However, 2019 and 2020 were the two best years for SAV in the Patapsco River since 2005 when 72% of the restoration goal was achieved, including SAV beds within Masonville Cove. Both 2004 and 2005 were generally very good years for SAV throughout the Chesapeake Bay region and the increases in coverage have been attributed to an accompanying population explosion and range expansion of dark false mussels (*Mytilopsis leucophaeata*). These filter feeders may have increased water clarity and allowed SAV coverage to significantly expand (L. Karrh, MD DNR, personal communication). In 2006, mussel populations declined, SAV beds disappeared in Masonville Cove and total area of SAV within the Patapsco decreased 83%. In 2010, there was no SAV in the entire Patapsco River.

The increase in SAV coverage seen in the Patapsco River in 2019 and the stability of coverage in 2020 follow the recent trends found throughout the Chesapeake Bay watershed. Expansions of SAV beds have been recorded in many tributaries over the past few years. Bay-wide, SAV coverage declined 38% in 2019, but the total area remained stable in 2020. Over 62,000 acres were observed bay-wide in 2020, which is one-third the restoration goal of almost 185,000 acres.

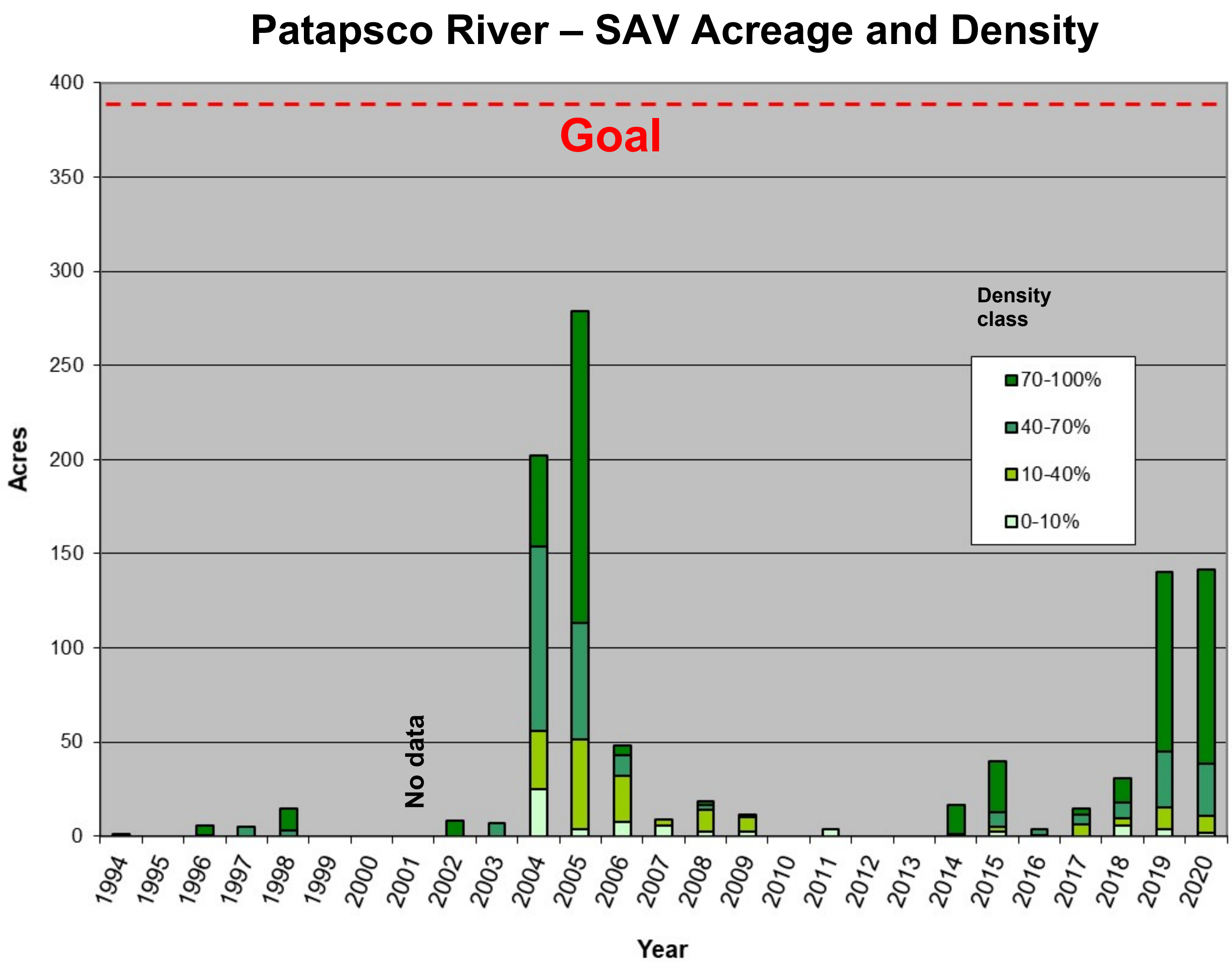

Figure 11. Total area and density of SAV in the Patapsco River between 1994 and 2020. (*Restoration goal is 389 acres)*

Pigments, Suspended Solids and Secchi Depths

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

Service visits were canceled and samples were not collected March, April, and May because of an enforced no entry policy due to the presence of nesting eagles. Furthermore, due to the COVID-19 pandemic and the State of Emergency declared by Governor Hogan, DNR suspended all field-related activities between March 13th and May 26th.

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: http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/SWM_QAPP_2020_2021_Draft_v9.pdf. Results of the laboratory analyses are presented graphically in Appendix A (Figures A-1 through A-3). Secchi depth measurements are presented in Figure A-4. The suspended sediments, pigments and Secchi depth data are also presented in Table A-1 of Appendix A.

Table 4. Deployment and calibration record for Masonville Cove continuous monitor in 2020.

Scheduled calibration date	Samples collected	Comment
January 7th, 2020	Yes	HAB sample collected
February 4th, 2020	Yes	Telemetry data reestablished following malfunction on January 18th
June 9th, 2020	Yes	Limited service visits resumed following enforced no entry policy due to eagle nesting site and suspension of all field activities due to COVID-19 pandemic; Telemetry data reestablished following sonde power failure on March 25th
July 9th, 2020	Yes	Regular service visits resumed
July 22nd, 2020	Yes	
August 6th, 2020	Yes	
August 19th, 2020	Yes	
August 21st, 2020	No	Telemetry data reestablished following malfunction on August 13th
September 1st, 2020	Yes	
September 16th, 2020	Yes	
October 1st, 2020	Yes	
October 14th, 2020	Yes	
October 29th, 2020	Yes	
November 10th, 2020	Yes	
December 8th, 2020	Yes	pH readings resumed following malfunction of probe on November 18th

Pigments

Chlorophyll values at Masonville Cove were generally below 20 µg/l during most of 2020. Three peaks in chlorophyll, greater than the 50 µg/l threshold indicative of a significant algal bloom, occurred in July, September, and October. The July and September peak values were 63.5 µg/l and 79.6 µg/l, respectively. The October peak value was 139.8 µg/l and was greater the 100 µg/l threshold for a severe algal bloom.

Pheophytin patterns mimicked those of chlorophyll in 2020. Peak pheophytin values coincided with peak chlorophyll values on July 22, September 1, and October 1. The pheophytin values in July and October were greater than 14 µg/l, while the September value was around 6 µg/l. All other pheophytin values for the year were below 5 µg/l.

Suspended solids

In 2020, suspended solids concentrations at Masonville Cove were generally higher through the months of July-October. Elevated values of suspended solids (greater than 15 mg/l) were observed on the same dates as peak chlorophyll concentrations, suggesting that algal cells contributed to the suspended matter on these dates. Higher concentrations of suspended matter also occurred in January, with a measured value of 14.7 mg/l. Suspended solids concentrations were less than 10 mg/l for the remainder of the year.

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 2020 was recorded on July 22 (0.3 m) when suspended sediments measured 16.0 mg/l and the chlorophyll concentration was 79.6 µg/l . The highest Secchi depth values in 2020 (>1.0 m), were observed in February, late October, and November, and represent periods of greater water clarity.

Ambient Water Quality

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

Salinity

The year 2020 started with January salinity values at Masonville Cove around 12 ppt. Salinity declined over the next 5 months, with the lowest average value for the year observed on June 9 (4.2 ppt). This low salinity period was followed by generally increasing salinity values, until a peak average salinity of 11.8 ppt was observed on October 14. After October 14, salinity values declined sharply, ending with measured values of approximately 4.5 ppt in December.

Dissolved oxygen

In 2020, dissolved oxygen concentrations in Masonville Cove followed a general seasonal trend of higher values (>10mg/l) in the cooler months (January-February and November-December) and lower values (<8 mg/l) in the warmer months (June-September). Dissolved oxygen measurements in the summer months also revealed marked differences between oxygen levels in the shallow surface waters and in the deeper bottom waters. In the summer months, surface measurements of dissolved oxygen were always greater than 5 mg/l and occasionally reached values as high as 10 mg/l. However, in this same time period, bottom water dissolved oxygen values frequently dropped below the 5 mg/l threshold that is considered necessary to support a healthy marine ecosystem. Average values of dissolved oxygen peaked slightly throughout the summer season on dates with coincident high chlorophyll values. These peaks may reflect greater photosynthetic activity during algal bloom conditions.

Water temperature and pH

Water temperatures also varied seasonally at Masonville Cove. Water temperatures ranging from 5.6 ℃ to 7.4 ℃ were measured from January through February 2020. As the weather warmed, water temperatures gradually rose to a peak value of 30.7 ℃ on July 22, and then declined steadily to around 5 ℃ on December 8.

Measured pH values at Masonville Cove fluctuated between 7.2 and 8.4 in 2020. Although average pH values were generally lower through the months of June-November, small peaks in average pH occurred during algal bloom events on July 22, September 1, and October 1, 2020.

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2020. 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 2020, algal and dissolved oxygen conditions were degraded as compared to prior years. Samples collected in the Patapsco River during algal blooms in January, June, July, and October did indicate the presence of two potentially harmful algal species, *Prorocentrum minimum* and *Karlodinium veneficum*. Finally, water clarity conditions in Masonville improved to the highest levels observed, but no submerged aquatic vegetation was found in the Cove. Thus, although habitat conditions in Masonville Cove may have improved in terms of water clarity, conditions remain poor for living resources in the upper Patapsco River.

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

<u>Appendix A</u>

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

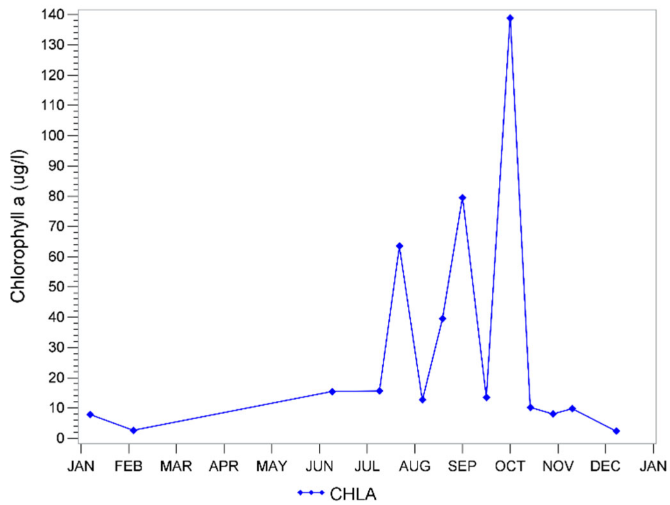

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2020.

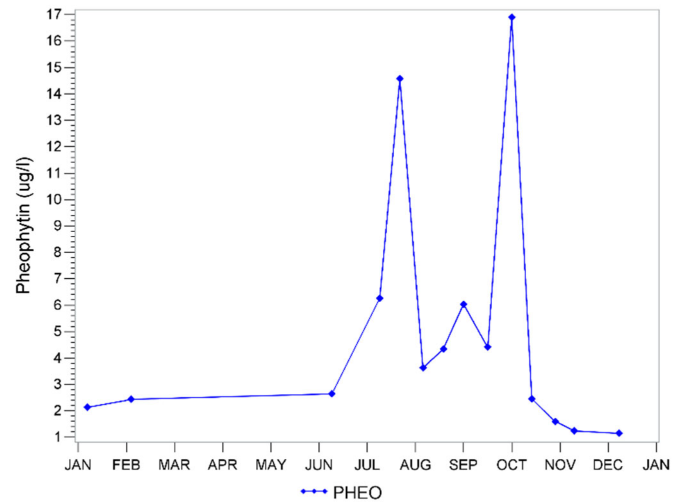

Figure A-2. Pheophytin concentrations at Masonville Cove in 2020.

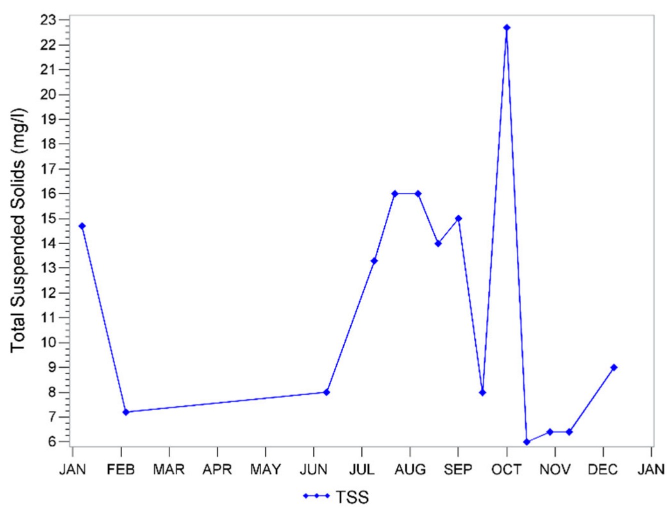

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2020.

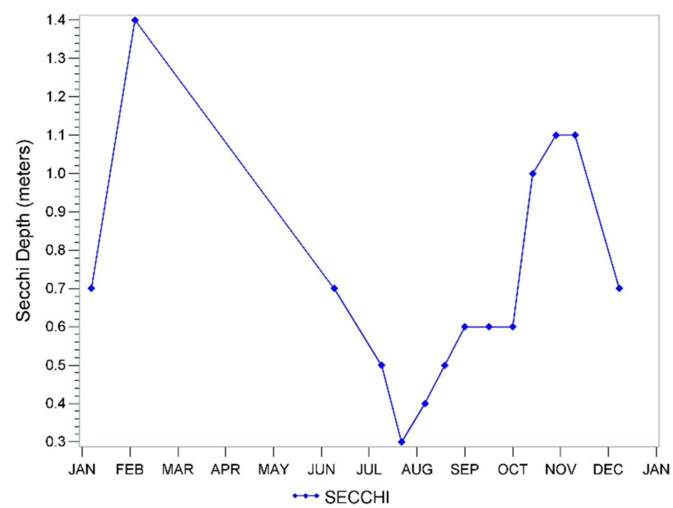

Figure A-4. Secchi depth at Masonville Cove in 2020.

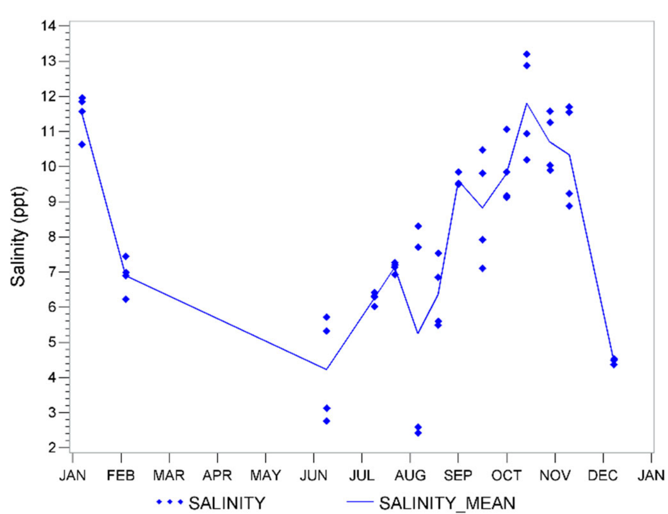

Figure A-5. Salinity concentrations at Masonville Cove in 2020.

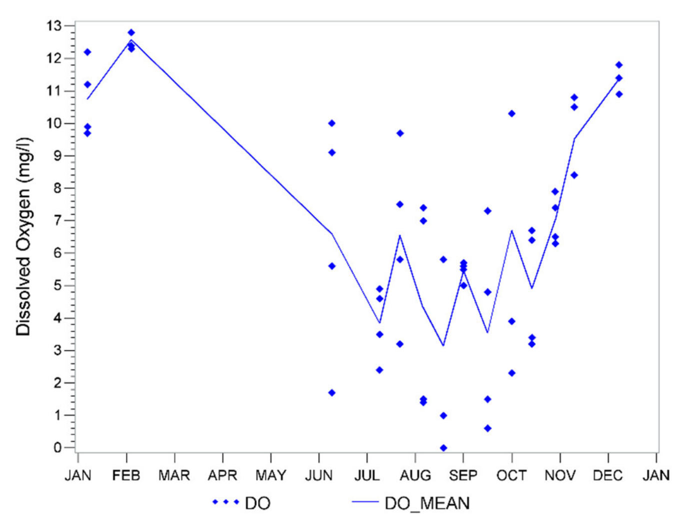

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2020.

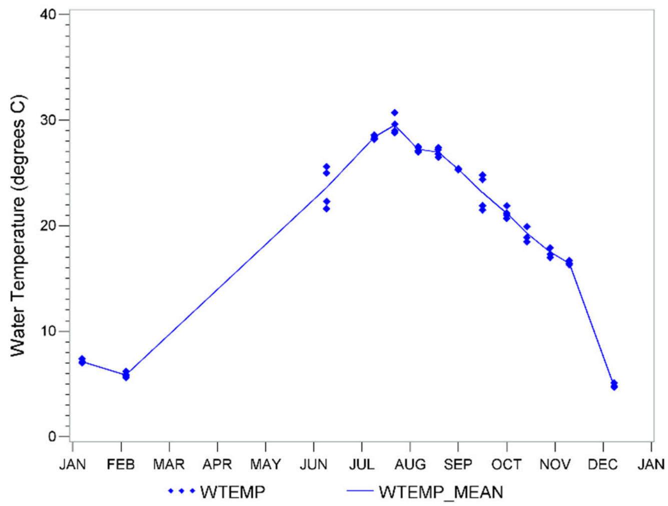

Figure A-7. Water temperature at Masonville Cove in 2020.

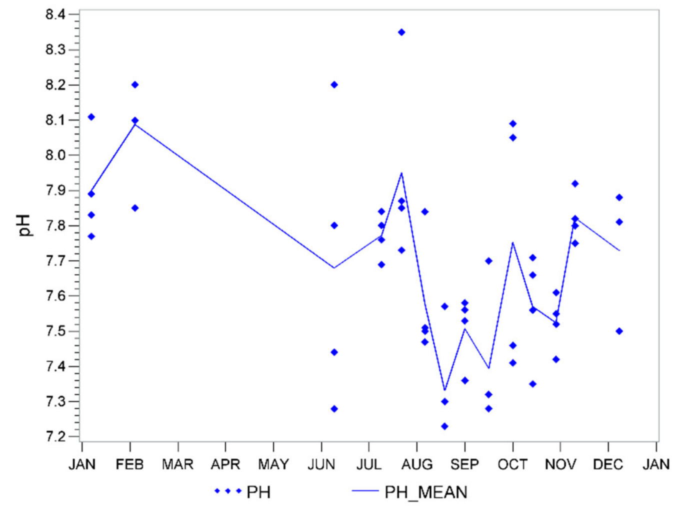

Figure A-8. Values of pH at Masonville Cove in 2020.

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 2020.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Pheophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
01/07/20	1	7.832	2.136	14.7	0.7
02/04/20	1	2.670	2.439	7.2	1.4
06/09/20	1	15.486	2.643	8.0	0.7
07/09/20	1	15.664	6.266	13.3	0.5
07/22/20	1	63.546	14.578	16.0	0.3
08/06/20	1	12.816	3.631	16.0	0.4
08/19/20	1	39.516	4.343	14.0	0.5
09/01/20	1	79.566	6.034	15.0	0.6
09/16/20	1	13.528	4.414	8.0	0.6
10/01/20	1	138.840	16.910	22.7	0.6
10/14/20	1	10.253	2.456	6.0	1.0
10/29/20	1	8.117	1.602	6.4	1.1
11/10/20	1	9.826	1.239	6.4[1]	1.1
12/08/20	1	2.403	1.148	9.0	0.7

1) Poor replication between pads, mean reported

Table A-2. Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2020 (continued on next page).

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
01/07/20	0.5	12.2	8.11	10.63	7.0
01/07/20	1.0	11.2	7.77	11.85	7.0
01/07/20	1.5	9.9	7.89	11.57	7.1
01/07/20	2.0	9.7	7.83	11.96	7.4
02/04/20	0.5	12.4	8.10	6.23	6.2
02/04/20	1.0	12.3	7.85	6.90	5.9
02/04/20	1.5	12.8	8.20	6.99	5.8
02/04/20	2.1	12.8	8.20	7.45	5.6
06/09/20	0.5	10.0	8.20	2.76	25.6
06/09/20	1.0	9.1	7.80	3.13	25.0
06/09/20	1.5	5.6	7.44	5.32	22.3
06/09/20	2.1	1.7	7.28	5.72	21.6
07/09/20	0.5	4.9	7.84	6.02	28.6
07/09/20	1.0	4.6	7.69	6.30	28.3
07/09/20	1.5	3.5	7.80	6.42	28.5
07/09/20	2.2	2.4	7.76	6.31	28.2
07/22/20	0.5	9.7	8.35	6.93	30.7
07/22/20	1.0	7.5	7.87	7.20	29.6
07/22/20	1.5	5.8	7.85	7.14	29.0
07/22/20	2.0	3.2	7.73	7.27	28.8
08/06/20	0.5	7.4	7.84	2.43	27.1
08/06/20	1.0	7.0	7.47	2.59	27.0
08/06/20	1.5	1.5	7.50	7.71	27.4
08/06/20	2.1	1.4	7.51	8.31	27.5
08/19/20	0.5	5.8	7.57	5.49	26.8
08/19/20	1.0	5.8	7.30	5.60	26.5
08/19/20	1.5	1.0	7.23	6.85	27.2
08/19/20	2.1	0.0	7.23	7.54	27.4
09/01/20	0.5	5.6	7.58	9.52	25.4
09/01/20	1.0	5.7	7.36	9.85	25.3
09/01/20	1.5	5.5	7.56	9.50	25.4
09/01/20	2.0	5.0	7.53	9.53	25.3
09/16/20	0.5	7.3	7.70	7.11	21.5
09/16/20	1.0	4.8	7.28	7.93	21.9
09/16/20	1.5	1.5	7.28	9.82	24.4
09/16/20	2.1	0.6	7.32	10.47	24.8

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen, pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2020.

Date	Sample Depth (m)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
10/01/20	0.5	10.3	8.09	9.13	21.0
10/01/20	1.0	10.3	8.05	9.17	20.7
10/01/20	1.5	3.9	7.41	9.85	21.2
10/01/20	1.8	2.3	7.46	11.06	21.9
10/14/20	0.5	6.4	7.66	10.19	18.9
10/14/20	1.0	6.7	7.35	10.94	18.5
10/14/20	1.5	3.2	7.56	12.87	19.9
10/14/20	2.0	3.4	7.71	13.20	19.9
10/29/20	0.5	7.4	7.61	9.90	17.3
10/29/20	1.0	7.9	7.42	10.04	17.0
10/29/20	1.5	6.5	7.55	11.26	17.9
10/29/20	1.8	6.3	7.52	11.58	17.9
11/10/20	0.5	10.5	7.92	8.88	16.7
11/10/20	1.0	10.8	7.82	9.23	16.3
11/10/20	1.5	8.4	7.75	11.55	16.4
11/10/20	2.0	8.4	7.80	11.70	16.4
12/08/20	0.5	11.4	7.81	4.37	4.8
12/08/20	1.0	11.8	7.50	4.49	4.7
12/08/20	1.4	10.9	7.88	4.53	5.1